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THE GATHMANN 18-IN. TORPEDO GUN failed, on Nov. 16, to demolish the 11½-in. Kruppized steel target at Sandy Hook, by the explosion of 500 lbs. of wet guncotton against the face of the target. In the first shot the fulminate and dry guncotton charge did not explode the wet guncotton, owing, says the inventor to faulty packing. The second shot did explode the full charge; but the only result was a dent in the face of the armor and the plate was driven back about 12 ins. at one end and 33 ins. at the other, and the backing slightly displaced. The third shot, with 310 lbs. of powder, was more successful, as it fractured the plate and pretty effectually wrecked the target. The range was one mile. The general opinion was that the force of the exploding 500 lbs. of wet guncotton was largely expended upon the air instead of the target. On the other hand, the 12-in. government rifle, with which the Gathmann gun was competing, made an excellent record on a duplicate target. A 12-in. Midvale armor-piercing projectile, loaded with the secret compound called "Explosive D," was fired. It pierced the 11½ ins. of armor and exploded beyond, totally wrecking the backing. In a trial on Nov. 18, with this 12-in. gun, a charge of 25 lbs. of Maximite was put in the shell. This shot passed through an uninjured part of the plate and exploded while passing through, cracking the plate vertically and horizontally. Another projectile, loaded with 20 lbs. of "Explosive D," completely wrecked another part of this target and threw a piece weighing nearly one ton a distance of 200 ft.

THE PROPOSED NAVAL STATION AT OLONGAPO, Subig Bay, Philippine Islands, is estimated to cost fully $30,000,000, according to the Special Board presided over by Rear Admiral H. C. Taylor. Exclusive of defensive works, signal station, water supply, coaling station, magazines, hospital and barracks and native village, the establishment at Olongapo will cost $19,350,500. To equip the station for efficient work of repair and outfit of vessels, pending general development, will cost $12,903,500. The isolation of the station, and the necessity for self-dependence in everything—as all supplies must come from a distance, vastly enhances the cost.

THE PAN-AMERICAN EXPOSITION results in a final net loss to the exposition company of $3,326,000. The total amount expended by the exposition company was $8,860,757, and the receipts from admissions after May 1 were only $2,467,066. Receipts from concessions were $3,611,522; but nearly all the concessionaires lost money.

THE WORLD'S NAVAL GROWTH is noted in the last annual report of the Secretary of the Navy, and it is not encouraging to American growth in the same direction. The two tables follow; the first shows the tonnage laid down in 1901; and the second, the new tonnage authorized during the current fiscal year:

TABLE NO. 1.

Nation.	Battleships. Tons.	Cruisers. Tons.	Torpedo vessels. Tons.	Total. Tons.
England	30,000	81,920	4,700	116,620
France	....	35,100	6,772	41,872
Germany	11,800	9,770	4,900	26,470
Italy	....	....	....	....
Japan	....	6,400	5,903	12,303
Russia	19,500	31,785	3,550	54,835
United States	....	23,000	840	23,840

TABLE NO. 2.

Nation.	Battleships. Tons.	Cruisers. Tons.	Torpedo vessels. Tons.	Total. Tons.
England	49,500	72,760	4,400	126,660
France	29,730	12,550	5,980	48,260
Germany	26,000	17,270	4,200	47,470
Italy	25,250	....	....	25,250
Japan	....	....	....	....
Russia	13,500	23,600	2,100	39,100
United States	....	....	....	....

NAVAL ESTIMATES for the next fiscal year, aggregate $38,000,000, according to the annual report of the Secretary of the Navy. An increase of 14 fighting ships and eight auxiliary ships is asked for, and an addition of 450 officers, 3,000 enlisted men and 750 marines to the present force. Secretary Long also recommends an increase of 50% in the number of midshipmen under instruction. The Department recommends the building of three first-class battleships, two first-class armored cruisers, three gunboats of 1,000 tons displacement, three of 200 tons, three picket boats of 600 tons, three steel training ships of 2,000 tons, one collier of 15,000 tons, and four tugboats. Secretary Long strongly advocates the substitution of an astronomical administration for the naval observatory for the time-honored practice of placing a naval line officer over the astronomer, and shifting this naval head about every three years. He says that the average term of service of the chief of the Greenwich observatory is 28 years; at Harvard it is 15 years, and at the U. S. Naval Observatory only a little over 3 years. As there is no vital relation between the navy and the observatory he recommends a change in law, so that a civilian astronomer especially qualified for the office may be placed in absolute charge.

THE BRISTOL, ENGLAND, DOCK EXTENSION is to cost $10,000,000, and a like sum has already been expended upon this dock system by the corporation of Bristol. According to Mr. F. B. Girdlestone, general manager of the Bristol; Avonmouth and Portishead docks, at Bristol, the proposed work includes a new dock covering 32 acres, approached by a lock 850 ft. long, 85 ft. wide and with not less than 36 ft. of water on the sill at ordinary tide. To this will be added freight sheds, elevator, and graving-dock, all equipped with electric motors of the latest type. These docks connect directly with the Great Western and the Midland railway systems. Mr. Girdlestone claims that the port of Avonmouth is superior to either Southampton or Liverpool, and coal is cheaper, with lower railway rates to Birmingham than Liverpool. It is being equipped with the most modern appliances for handling the cargoes of ships of 12,000 tons capacity. Mr. Girdlestone is now in this country studying terminal equipment at our chief ports.

THE HAVANA SEWERAGE AND PAVING CONTRACT, it is now reported, has been awarded to Mr. Michael J. Dady and associates after all. According to reports, Mr. Dady stopped the award of the contract to McGivney & Rokeby, the lowest bidders, by offering to reduce his bid by $572,036, claiming that he added this 5% because he thought payment would be made in bonds at a discount of that amount.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a collision on the Great Northern Ry., near Culbertson, Montana, on Nov. 16. An extra freight, when rounding a sharp curve, collided with a work train. According to reports, a score or more of workmen, all Japanese, were killed.——An accident, serious in its possibilities, occurred on the Third Ave. line of the Manhattan Elevated Ry. in New York at about 6 p. m. of Nov. 13, 1901. An uptown train of five cars packed with passengers ran into an empty train ahead of it at Chatham Square; the engine was derailed, jumped the guard stringers and turned sidewise, but stopped just at the edge of the ties. The couplings of the first three cars broke, and none of the cars were derailed. No one was hurt, but a panic was narrowly averted among the occupants of the cars. The line at this point runs along just at the edge of the sidewalk of the Bowery, and the street was crowded with people at that hour. More favorable conditions for an appalling railway accident can hardly be imagined. The accident was caused by the engineer of the colliding train disregarding a semaphore signal set against him in plain view. It is said he lost his nerve completely.

THE FALL OF FOUR ROOF TRUSSES just erected for the new power house at the University of Chicago, caused the death of one man and the injury of five others. In view of the high wind the men were putting in lateral bracing to prevent the trusses from being blown over, when the accident occurred. The trusses were of 38-ft. span and weighed about 1,000 lbs. each.

A RUNAWAY FREIGHT TRAIN WAS STOPPED, on May 2, 1901, by John Riley, a locomotive engineer, on the Pittsburg Division of the Pennsylvania Railway. Riley's engine was standing at Altoona, when he was notified by the telegraph operator to get out of the way as a runaway train of 58 freight cars was coming down the mountain grade to Altoona. Instead of doing so Riley ordered his fireman out of the engine and started up the grade to meet the train. When he saw it approaching he reversed his engine and allowed the train to catch him when the speed was about equal. He was unable to bring the train to a full stop, and he partly wrecked his own engine and two others in front of him; but the damage was slight compared to what might have resulted from the unchecked train. In recognition of his "courage, judgment and high sense of duty," the Directors of the Pennsylvania Railroad Co. presented John Riley with a suitably inscribed gold watch, worth $1,000, and a check for $500. At the same time Engineer William Black and Conductor James Lundy were presented with $200 each for an act of bravery performed on Feb. 26, 1901. They started in pursuit of a runaway engine and overtook it when running at a terrific speed, coupled to it and gradually brought it to a stop.

THE GERMAN HIGH-SPEED ELECTRIC RAILWAY experiments have resulted up to the present in a speed of 93½ miles an hour, according to a newspaper despatch. Current was used under a line pressure of 10,000 volts. It is claimed that with some changes in the line this speed would be entirely practicable.

FAST TIME WITH AUTOMOBILES was made over a mile straightaway course on the Ocean Parkway, Brooklyn, N. Y., on Saturday, Nov. 16, 1901, in a series of races held under the auspices of the Long Island Automobile Club. The fastest time, 0.51⅘ for the mile, was made by a 40-HP. gasoline machine manned by Mr. H. Fournier. The best previous time made by an automobile was the record of 1:06⅘, made by Mr. A. Winton over the Grosse Pointe track at Detroit, on Oct. 24, 1901. Two other machines of the same class as Fournier's, manned by Mr. F. P. Keene and Mr. A. C. Bostwick, respectively, made the distance in 0:54⅘ and 0:56⅘, respectively. Two other noteworthy performances were that of an electric vehicle, driven by Mr. A. L. Riker, time 1:03, and that of a small four to six horse-power steam vehicle, driven by Mr. S. T. Davis, Jr., time 1:15.

AUTOMOBILES ACROSS THE CAUCASUS, for carrying the Russian mail, are to supplant the present transport by post-horses, changing every ten miles. This mail route traverses the famous Darial Pass connecting Tiflis, in Asiatic Caucasia, with Vladikavkaz, the railway station, on the north side of the mountains. The pass is about 160 miles long, and the road summit is 8,000 ft. above the sea, in a glacier region. It is maintained as a military road by the Russian authorities, and is the only road crossing the Caucasus between the Black Sea and the Caspian.

PUMPING BY ELECTRIC POWER is supplanting steam at the Calumet & Hecla copper mining properties, and the stamp mills are also to be operated by the same electric power. Electric pumps are exclusively used in the South Hecla branch of the mines, and at the Calumet branch steam pumps are employed with electric pumps as auxiliaries. The General Electric Co. is conducting experiments at the Quincy mine with electric traction. Electric trams have been in operation for several years in the Pioneer iron mine and have recently been put into the Hibbing mine of the Lake Superior Consolidated Iron Mines.

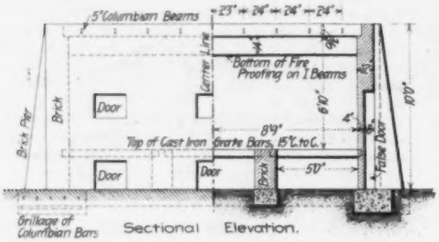
THREE NATURAL GAS-PUMPING STATIONS, near Hartford City, Ind., are described in the Muncy "Star." Two of these belong to the Ft. Wayne Gas Co., and one to the Kerlin Bros., of Toledo, O.; they cost about $50,000 each. Each station is equipped with two sets of Corliss compound engines, which drive four compressors having a capacity of 21,000,000 cu. ft. of gas forced to Ft. Wayne every 24 hours. There are six boilers of 1,100 HP. each at each station. The water supply for these stations is a unique feature. Artificial lakes, covering two acres each, have been constructed, and into these water is pumped by gas-pressure from deep wells. From the lake the water is taken to the condensers, and then sent out again to cool. By this means the water is used over and over again.

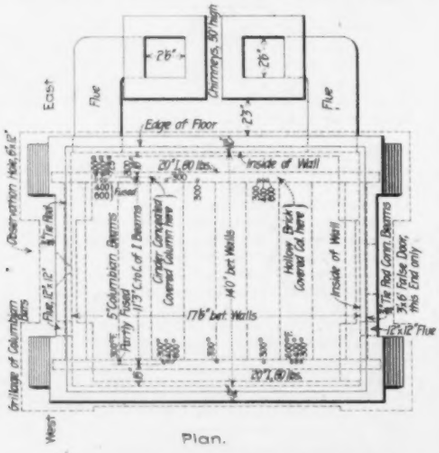
TRACTION BY COMPRESSED AIR is being installed at the Massachusetts Cotton Mills, at Lowell, Mass., as the result of the factory mutual insurance companies objecting to traction machines operated by steam or electricity on account of the fire hazard involved. About 3½ miles of trackage outside are to be thus operated, as well as about 2 miles under cover.

FIRE AND WEIGHT TESTS OF COLUMBIAN FIREPROOF FLOOR; BOSTON, MASS., JULY, 1901.

By Frank P. McKibben,* Assoc. M. Am. Soc. C. E.

The accompanying illustrations show the method of conducting a combined fire, water and weight test of Columbian fire proof floor construction. The object of the tests was to demonstrate to the engineers of the Boston & Albany R. R. the capacity of the Columbian system when under heavy loads to resist the action of fire and water.





As shown by the plan, Fig. 1, the testing plant consists of a brick house covered with the floor to be tested. The house was built of old bricks with lime mortar, and measured 14 × 17½ ft. inside. The grate covered the entire area just mentioned. The floor to be tested was carried principally by two 20-in. 80 lb. beams spaced 11 ft. 3 ins. c. to c. To prevent inward deflection of the top flanges the two beams were connected at each end with one ¾-in. rod 3 ins. up from the bottom flange; and at the center of each beam there were two rods running outward and properly anchored. These rods passed through the webs of the beams, one 6 ins., the other 3½ ins. down from the top flange. No buckling of the beams was noticed during the tests.

The span of the floor was 11 ft. 3 ins. The floor was the ordinary form of the Columbian system, consisting of 5-in. Columbian ribbed bars spaced 2 ft. c. to c., and embedded in 8¼ ins. of stone concrete. On the under side of this stone concrete was a veneering of cinder concrete. For one-half of its length the bottom flange of each beam was protected by the Columbian cinder concrete beam covering. At the request of the engineers of the railway company the other half of each beam was covered with "mac-ite" blocks and wrapped with expanded metal. The covering of the east beam was plastered with a thin coat of Portland cement mortar. On the west beam the "mac-ite" blocks and the joints between the Columbian cinder concrete slabs were also plastered.

All cinder concrete was mixed one part of Alpha Portland cement to seven parts cinders; stone concrete, one part cement, 2½ parts sand and five parts broken stone.

To test the fire-resisting qualities of the cinder concrete column covering two 8-in. I-beams were set up in the test house. One was covered with cinder concrete and was finished to 9 × 13 ins. At the request of the engineers of the railway the other column was protected by hollow bricks. It was finished to 12 × 16 ins., giving 4 ins. outside of metal.

The tests conducted were as follows: Floor loaded to 1,000 lbs. per sq. ft.; load reduced to 400 lbs. per sq. ft.; while thus loaded with 400 lbs. per sq. ft. two fire tests were applied; load then increased to 1,650 lbs. per sq. ft.; entire load then removed.

At 45 days after the floor was laid the loading

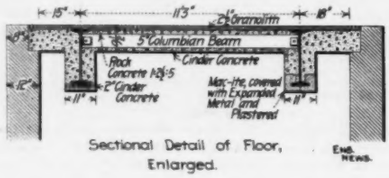


FIG. 1. DETAILS OF TEST HOUSE AND FLOOR CONSTRUCTION; TESTS OF COLUMBIAN FIRE-PROOF FLOOR FOR BOSTON & ALBANY R. R.

was begun, and after two days the loading reached 1,000 lbs. per sq. ft. Building bricks were used as load, and great care was taken to arrange the load in isolated piers, Fig. 2. As soon as 1,000 lbs. per sq. ft. was reached on July 8 the loading was reduced to 400 lbs. per sq. ft. The maximum deflection during the above test was ⅜ ins.

While loaded with the 400 lbs. per sq. ft. a fire of 2 hours 15 minutes' duration was maintained within the test house. This fire was then quenched and a second fire of 38 minutes' duration was applied.

deflection at the end of fire tests was ⅞ in. Of this 15-16 in. was due to the fire.

After the first fire the ceiling, beams and columns were subjected to the fire stream for 4½ mins., and after the second fire 4 mins. Until the application of the water the floor had suffered no apparent injury. When the stream was turned on the cinder concrete was somewhat washed, but no serious injury was done. The cinder concrete beam and column coverings stood the fire and water well. The place of greatest injury was on the side of the west I-beam where one place about 4 ins. square was washed to a depth of ¾-in. One corner of the column covering was also badly washed. The hollow brick column covering suffered very badly.

The first application of water removed most of the mac-ite from the under side of the I-beams, Fig. 3. This left those parts of the beams which had been covered with mac-ite exposed to the action of the second fire. Where the water did not strike the cinder concrete was uninjured.

Several cracks developed in the walls of the test house during the fire, and, as was to be expected, the joint between the side walls and concrete floor opened up. Two hair cracks which had appeared in the ceiling under 800 lbs. per sq. ft. were opened slightly during the fire.

On July 10, about 36 hours after the fire tests, the final test was begun. The load of 400 lbs. per sq. ft. was increased until, on July 13, it was 1,650 lbs. per sq. ft. over the entire area of the floor, 11¼ × 17½ ft. At this point, on account of the numerous cracks which had developed in the brick walls of the test house, it was deemed unwise to increase the loading further. The floor showed no signs of collapse. The maximum deflection under 1,650 lbs. per sq. ft. was 1⅝ ins. This represents net deflection, i. e., after deducting the deflection due to the walls and I-beams. The entire load was then removed, and it was found that the last test had increased the size of cracks in the ceiling, and had produced several additional ones. With the exception of two cracks in the ceiling, which ran at right angles to the

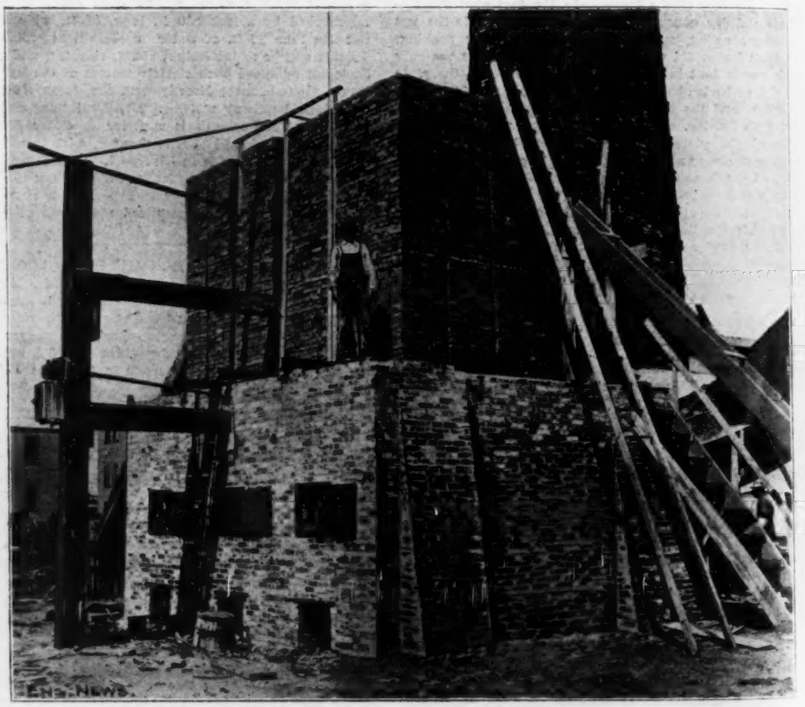


FIG. 2. VIEW OF TEST HOUSE, SHOWING LOAD OF 1,000 LBS. PER SQ. FT. IN PLACE; TESTS OF COLUMBIAN FIRE-PROOF FLOOR FOR BOSTON & ALBANY R. R.

The maximum average temperature of the first fire was 1,715° F., and of the second 1,706° F. The fire stream was supplied from a fire engine, nozzle 1⅛ ins. in diameter. The pressure at the nozzle varied from 53 to 57 lbs. per sq. in. The Columbian bars for a distance of about 2 ft., nearly all of the cracks ran parallel with those bars. As a result of these tests the Columbian floors are being used in the new warehouse of the Boston & Albany R. R. in East Boston.

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WATER-TUBE BOILER EXPLOSIONS IN AN ENGLISH ELECTRIC LIGHT STATION.

One of the tubes in a Babcock & Wilcox boiler in operation at the Sardinia St. station of the Metropolitan Electric Supply Co. of London, burst on Nov. 17, 1900, permitting the contents of the boiler to escape.

At the time of the accident, this boiler was one of 12 that were connected and supplied steam to three engines. The fire in the boiler was banked, no steam being drawn at the time. Five minutes before the explosion the pressure gage registered 150 lbs., the gage glass being half full.

The boiler, known as No. 1, was eleven years old. It had 126 wrought-iron lap-welded tubes 4 ins. in diameter, of No. 9 B. W. G. expanded into cast headers, two 3-ft. steel steam-drums and a cast mud-drum. The boiler was designed for a working pressure of 150 lbs. per sq. in.; on completion it had been tested to 225 lbs. by hydraulic pressure. The insurance company had limited the working pressure to 170 lbs. per sq. in., but the safety valves were set at 160 lbs.

On Jan. 8, 1901, a very similar explosion occurred in another boiler at the same station. This boiler, known as No. 7, was also a Babcock & Wilcox water-tube boiler, similar in construction to boiler No. 1, and was ten years old. It was, like the other, designed to be worked at 150 lbs. pressure, having been tested to 225 lbs. on completion. The insurance company allowed 175 lbs., but the safety valves were set to blow off at 160. The tubes for both boilers, according to the makers, had been tested by the makers to 1,000 lbs. per sq. in.

As is its custom, the Board of Trade instituted an investigation into the cause of these explosions. The report of the commissioners has recently been made public, and contains some items of interest. According to this report, the boilers were fed with water supplied by the New River Co. The following analysis of the water is given:

	Per gallon.
Silica	0.39 grs.
Oxide of iron	0.25 "
Sulphate of lime	3.40 "
Carbonate of lime	14.20 "
Carbonate of magnesium	0.88 "
Nitrate of magnesium	0.66 "
Chloride of sodium	3.28 "
Total inorganic matter in solution	23.06 "

It was found that the internal feed pipes, as well as the drums, were cleaned every six or eight weeks; the tubes were thoroughly cleaned out every year. The material of the tube was found to be of good quality, and the weld sufficient. The following items are extracted from the report and refer directly to boiler No. 1. The respective clauses of the report on the accident to boiler No. 7 are quite similar:

NATURE OF THE EXPLOSION.—The fourth tube from the bottom in the seventh header from the left side facing the boiler front, burst open along its right side for a length of about 3 ft. 8 ins., and both ends of the tubes were loosened in the headers. The front end of the rupture was rather more than 2 ft. from the front header, and the tube was practically opened out flat for a length of 3 ft. 6 ins. Through the opening thus formed the contents of the boiler escaped, as well as a quantity of steam from 12 other boilers which were connected with the one that exploded. The rush of steam and water blew off both tube doors and one of the fire doors, and also displaced a quantity of brickwork at the front of the boiler.

CAUSE OF THE EXPLOSION.—The explosion was caused by the tube having become so weakened by overheating as to be unable to resist the steam pressure, and this overheating was caused by an accumulation of deposit in the tube, which prevented the proper circulation of water through the tube.

The conclusions of the commissioners are expressed as follows:

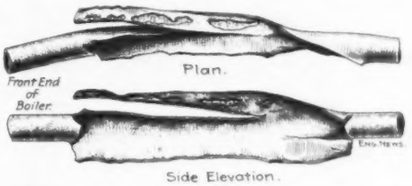
Suitable water was not used for feeding the boiler, and the boiler was not thoroughly or properly cleaned or examined at sufficiently frequent intervals. We have to answer this question in the negative, because, having regard to the way in which the boiler was used—sometimes standing with its fires banked and not supplying steam—it was very likely that deposit would rapidly form, especially having regard to the nature of the water that was used. Having regard to both these considerations, we think it ought to have been cleaned out at more frequent intervals. The boiler was not periodically tested by hydraulic pressure for the purpose of examination. Such test as it was subjected to, after repairs had been executed, was not sufficient. Proper and sufficient measures were not taken to ensure that the boiler was being worked under safe conditions, inasmuch as proper and sufficient care was not taken to see that it was provided with proper feed-water, and properly cleaned, having regard to the feed-water that was used.

The report then goes on to pronounce the engineer in charge of the station and the chief engineer of the Metropolitan Electric Supply Co. not guilty of neglect in the matter.

The report on the explosion in boiler No. 7 concludes with the following remarks:

We have been requested to favor the Board of Trade with our views as to the desirability of subjecting boilers of the water-tube type to hydraulic pressure. We assume that this question is asked with a view to obtain our opinion as to the desirability of the application of such a test as a means, although perhaps not the sole one, of examination. It is conceded that it is impossible to detect every blemish that may perchance exist in the inside of the tubes without withdrawing them. We gather from what we have learnt in these two recent investigations that the main risk of explosion in boilers of this type is from the existence of deposit in the tubes rendering them liable to become overheated, or from corrosion; and we have already pointed out that in our judgment it is necessary, for the purpose of ensuring the safe working of such a boiler, that it should be fed with water from which such an accumulation of deposit could not be formed, and it follows, also, with water that would not produce corrosion. We have formed the opinion that the water test, which of course should always be applied after repairs to ascertain that the joints, etc., are tight, although a useful adjunct to other forms of examination, should always be used with great care, and moreover, by competent persons, and should never be used higher than at twice the working pressure of the boiler test in attempting to discover a defect the boiler might be over-strained and weakened. It seems to us that the same consideration with regard to the application of the water test to boilers generally applies to those of the water-tube type. The main danger to be apprehended in the tubes is that which arises from defective circulation owing to the presence of scale. This danger a water test would not reveal, and we fear that if such a test was recommended as an examination, there would be danger of neglect in opening and thoroughly cleaning the tubes. We, therefore, do not think it is desirable to subject boilers of this type to periodical tests by hydraulic pressure as a method of examination, although we certainly recommend that such a test should be applied to not less than one and a half times the working pressure after the boiler has been opened out for cleaning and thorough examination.

Howard Smith, J. H. Hallett, Commissioners.



Appearance of Burst Tube of No. 1 Boiler, Sardinia St. Station, Metropolitan Electric Co., London.

In modification of these remarks, the following memorandum was subsequently appended to the report:

To the Assistant Secretary, Board of Trade:

We desire, in order that our observations as to the desirability of the application of water test as a means of examination of boilers of this type may not be misunderstood, to add that, when a boiler has been carefully examined, and the elastic limit of the material has been ascertained by a properly qualified person, the application of the hydraulic test as an additional security may be safely left to his discretion; but we are of opinion that in no other circumstances should it be used, as in the hands of an unqualified person it might be a fruitful source of danger.

As before stated, we regard this test, when properly and judiciously applied, as a useful adjunct to examination, but we feel that to subject all boilers of this type to periodical hydraulic tests as a means of examination might lead to the adoption of such a test to the exclusion of other means which should, in our opinion, be taken to ensure the safe working conditions of these boilers.

The means which we recommend are as follows:

The use of suitable feed water.

Frequent examination of the tubes until proper periods for thorough cleaning have been ascertained.

The cleaning of all the tubes at these periods, and their examination after such cleaning by a competent person.

Abstention from forcing the fires, so that the natural circulation of the water in the boilers may not be interfered with.

Withdrawal of some of the tubes, and cutting them for examination, from time to time.

The substitution, as opportunity offers, of solid-drawn steel tubes for lap-welded iron tubes.

With regard to the intervals at which the tubes should be cleaned out, we desire to call attention to the fact that water in a boiler, when standing or under banked fires, is liable to deposit the same, or even a larger quantity of solid matter, than in a boiler at work under steam pressure.

The preceding information is abstracted from "The Electrician" for Sept. 6, 1901, in which nearly the full text of the two reports is given.

FIG. 3. INTERIOR OF TEST HOUSE, SHOWING EFFECTS OF COMBINED FIRE AND WEIGHT TESTS; TESTS OF COLUMBIAN FIRE-PROOF FLOOR FOR BOSTON & ALBANY R. R.

39,200 TONS OF IRON ORE shipped in one day from Ashtabula to the Pittsburg furnaces, is a new record made on the Jamestown & Franklin Branch of the Lake Shore system, on Nov. 10. In all, 35 locomotives and 55 trains were handled in this 24 hours, in addition to ordinary business.

THE COEFFICIENT OF EXPANSION OF CONCRETE.*

By Wm. D. Pence, M. W. S. E.†

With the increasing use of concrete as a structural material, the demand for a definite knowledge of its physical characteristics becomes more and more urgent. Unfortunately concrete varies radically in quality with the character, proportioning and manipulation of its ingredients; and its so-called structural constants (such as the compressive strength or the coefficient of elasticity, which, in a sense, are an index of quality) of course suffer a like fluctuation. One constant, however, the coefficient of expansion, which probably varies but slightly, seems to have received scant attention in the laboratory, if one may judge from the dearth of published data on the subject. The purpose of this paper‡ is to throw some light on this point.

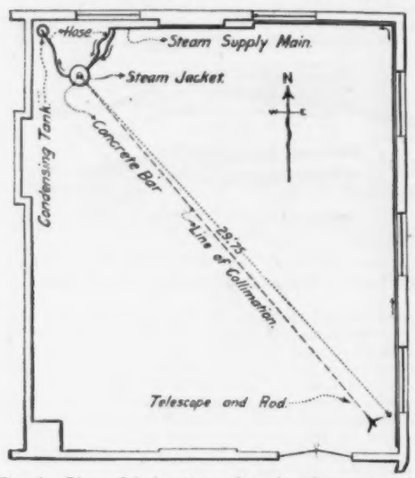


Fig. 1. Plan of Laboratory, Showing Arrangements for Testing Expansion of Concrete Bars.

SCOPE OF INVESTIGATION.—In planning the investigation it was at first proposed to determine the coefficient of expansion of each of a series of concrete bars differing both in the kinds of cement used and in the proportions of ingredients. It soon appeared, however, that considerable time would be required to perfect the apparatus, and it was early decided to restrict the first season's tests to a single brand of American Portland cement. In view of the fact that the investigation was suggested by the question of temperature stresses in the concrete-steel arch, it was finally deemed expedient to limit the scope of the investigation at the start still more closely and to direct attention for the time to a single grade or quality of Portland concrete representing best practice in the combined concrete-steel type of arch work. The selection of this standard of quality was simplified by the opportune appearance shortly before that time of a comprehensive article by Mr. Edwin Thacher, M. Am. Soc. C. E., entitled, "Concrete-Steel Bridge Construction" (Engineering News, Sept. 21, 28, 1899, pp. 179, 182, 202).

CONCRETE BARS.—Following is an extract from Thacher's specifications which governed the preparation of the concrete bars used in the investigation:

PORTLAND CEMENT CONCRETE.—The concrete shall be composed of clean hard broken stone or gravel, with irregular surface; clean, sharp sand and cement, mixed in the proportions hereafter specified. Whenever the amount of work is sufficient to justify it, approved mixing machines shall be used. The ingredients shall be placed in the machine in a dry state, and in the volumes specified, and be thoroughly mixed, after which clean water shall be added and the mixing continued until the wet mixture is thorough and the mass uniform. No more water shall be used than the concrete will bear without quaking in ramming. The mixing must be done as rapidly as possible and the batch deposited in the work without delay.

If the mixing is done by hand, the cement and sand shall first be thoroughly mixed dry in the proportions specified. The stone previously drenched with water shall then be deposited on this mixture. Clean water shall be added and the mass be thoroughly mixed and turned over until each stone is covered with mortar, and the batch shall be deposited without delay and thoroughly rammed until all voids are filled. The grades of concrete to be used are as follows: For the arches between skewbacks—1 part Portland cement, 2 parts sand, and 4 parts broken stone, or gravel, that will pass through a 1¼-in. ring; for the foundations, abutments, piers and spandrels—1 part Portland cement, 4 parts sand, and 8 parts broken stone, or gravel, that will pass through a 2-in. ring.

The proportions of 1 : 2 : 4 specified first above for the body of the arch proper were used in making the test specimens. Lehigh Portland cement was used the first year, and Medusa the second. In the first series of tests, hand-broken Bedford oolitic limestone was used; in the second the stone was obtained from a crusher at Kankakee, Ill.; the second series also included a bar of the unbroken stone. Local pit gravel of good quality was used; owing to its containing an excess of sand, a ¼-in. screen was used the first year and the coarser material was employed as gravel under the above specifications; in the second season's work, however, it was found by trial that 1 : 3 with the gravel in its natural state was equivalent to the 1 : 2 : 4 proportions screened, and the gravel was no longer screened. The first season's bars were made 6 × 6 × 24 ins., but owing to the great length of time required to heat the 36-sq. in. section to the center, the second series of bars were made cylindrical, 36 ins. long and 4 ins. diameter (12.5 sq. ins., or about one-third the original section).

After finishing the first series it was planned to undertake for the second season's work a somewhat elaborate series of tests, including several brands of cement, both Portland and natural, mixed in varying proportions, but in the interval between the two series inquiries as to the first results came from various quarters, chiefly from engineers who were interested in concrete-steel arch construction. It was, therefore, thought best to withhold the results first obtained until they could be carefully verified, and the second season's tests were directed to the latter end. An attempt was also made to extend the series to include natural cement concretes, but unfortunately the samples of both brands of natural cement tried seemed to have suffered in storage, for their activity was so reduced that the bars broke time and again in attempting to remove them from the mold. Tensile tests of these natural cements gave results which tallied with the behavior of the concrete. It may be stated that a third series is now in preparation, which includes not only a variety of qualities of concretes, but also a series of municipal construction materials.

METHOD OF INVESTIGATION.—The general method commonly employed to determine the coefficient of expansion was used, viz.: a bar of concrete of known length was subjected to an observed change of temperature, the increase of length determined, and the coefficient calculated. Previous to undertaking the tests, careful consideration was given to several methods of measuring the increase of length of the bar of concrete. It was at first intended to construct a special micrometer of large size, consisting of a metal bar packed to secure a fixed length, and having a projection at either end, one for fixed contact and the other to hold the micrometer screw. This plan was abandoned because of anticipated difficulties in securing uniform temperatures in both micrometer and concrete bar and also on account of the doubtful precision of the contact.

In the plan finally adopted a standard bar of steel or copper with known coefficient of expansion was subjected to identical changes of temperature with the bar of concrete, and the difference of expansion of the two bars was determined by the principle of the "optical lever." This difference in length, reduced to a unit of length and temperature, gave a correction to be applied to the known coefficient of the metal bar.

APPARATUS.—The apparatus in its final form included the following: (A) Two isolated foundations, on one of which rested the tripod shoes of the engineer's level used by the observer, and on the other a cast-iron tripod base for supporting the experimental bar; (B) a heating apparatus, consisting of a double-walled galvanized iron steam jacket, the inner air space forming the test bars, and communicating with the exterior by means of a square glass-covered window or aperture; (C) the test bar of concrete, supported tripod-like on three conical-pointed iron knobs molded into the lower end, and having a flat disk in the upper end upon which rested one end of the optical lever; (D) the steel or copper calibration bar or rod, pointed below and flat at the upper end to hold the other end of the optical lever; (E) the optical lever, consisting of a small tripod-like metal plate with mirror attached; (F) a standard thermometer suspended within the inner air space; (G) an incandescent electric light to illuminate the thermometer scale; (H) a graduated scale (leveling rod); (I) a telescope (engineer's level).

The steam jacket was located in the opposite corner of the room from the telescope and rod, as shown in Fig. 1. The general appearance of the apparatus is shown in the accompanying views, Figs. 2 to 4. Fig. 2 shows the steam jacket with the upper section and cover removed, exposing to view the concrete bar, with the standard bar held vertically alongside it by means of a wire near the top, and the optical lever in place on the upper ends of the bars. The electric switch seen in the window controlled the current to the incandescent light mentioned above. Fig. 3 shows the jacket assembled ready for a test; the details of the steam jacket, test bars, optical lever, etc., are given in Fig. 5. Fig. 4 shows the arrangement of the telescope and rod, the latter being so placed that the observer could see the target and read the rod himself, while his assistant attended to the apparatus in the opposite corner of the laboratory.

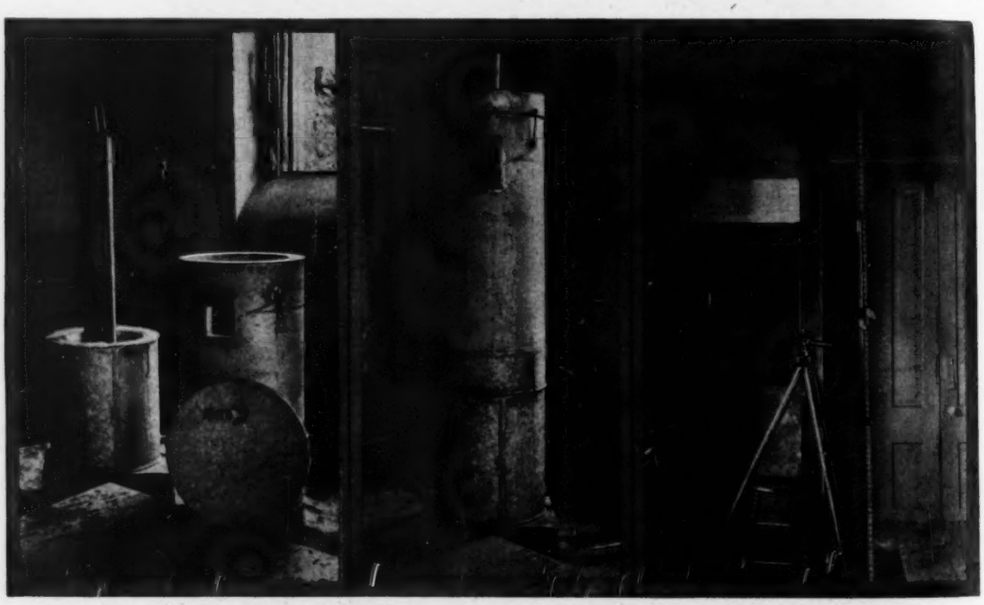


Fig. 2. Upper of Section of Jacket Removed. Test Bar and Optical Lever in Place.

Fig. 3. Steam Jacket Assembled. Apparatus Ready for a Test.

Fig. 4. Telescope and Rod Used in Tests.

TESTS OF EXPANSION OF CONCRETE BAR AT PURDUE UNIVERSITY.

Prof. Wm. D. Pence, Professor of Civil Engineering.

The principle of the optical lever is illustrated in the diagram, Fig. 5. The fixed line of sight (the line of collimation of the level) is directed to the mirror, which is so adjusted by the three screws of the plate as to give a reflected reading of the rod standing close beside the observer. Were the bars to expand with perfect equality, the mirror would simply move upward parallel to its first position, and the target reading would not change. With

*A paper read before the Western Society of Engineers on Nov. 20. Published by permission of the Society, which has copyrighted the paper. The cuts used are reproductions of those appearing with the original paper.

†Professor of Civil Engineering, Purdue University, Lafayette, Ind.

‡The experiments upon which this paper is based were conducted under the writer's direction by F. B. Ernst and R. W. Pearce (1899-1900), and by H. W. Brown and E. R. Houghton (1900-1901), as thesis work in the School of Civil Engineering, Purdue University, Lafayette, Ind.

an unequal expansion of the bars, however, one end of the lever rises more than the other, and the angular movement of the reflected ray is double that of the mirror or lever plate to which it is attached. In these tests it is desired to know the difference in linear expansion of the bars, and not the angular change. This linear difference, x, shown in the diagram on Fig. 5, is found by applying to one-half the target movement, r, the known ratio of the lever arm, a, to the distance from the mirror to the level rod, L. For the sake of simplicity this diagram is drawn as if the initial line were reflected back directly to the observer's eye in the first observation, and with the normal line of the mirror in a horizontal position in the second sighting. With these assumptions the triangles are seen to be rigidly similar, but with the wide contrast in the distances a and L the lines of sight may depart quite materially from these simple relations without affecting the results perceptibly. In these tests the desired distance x was the 1-357th part of the target movement.

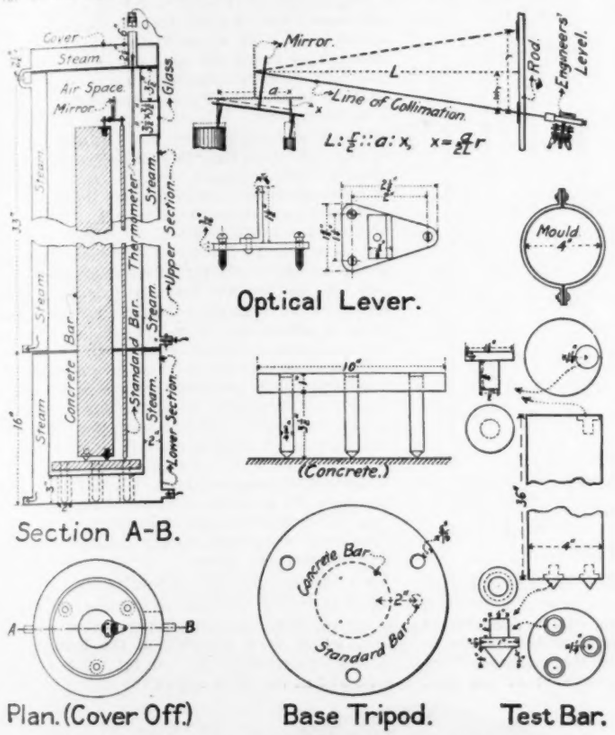


FIG. 5. DETAILS OF APPARATUS FOR TESTING EXPANSION OF CONCRETE BAR.

To meet the necessity of holding the line of collimation as steady as possible, each tripod shoe of the instrument was surrounded by a batch of neat Portland cement mortar deposited on the concrete base. As a further precaution after the sighting was once established, the adjusting screws of the level tube were changed to bring the bubble precisely in the center; although the radius of curvature of the vial was 115 ft., it was found that the bubble was practically stationary day after day. However, notwithstanding this evident stability of the line of sight, the observer was very careful to avoid disturbing the telescope during a test.

DETAILS OF A TEST.—The progress observed in making a test was as follows: The lower section of the jacket with the legs of the tripod base inserted in the holes was placed on the concrete foundation so that the galvanized iron can did not touch the tripod at any point. The concrete bar was set centrally on the cast-iron base plate with its top plug on the side towards the telescope. The steel or copper calibration rod was then wired in a vertical position alongside the concrete bar and the mirror tripod or lever was set in place on top of the bars, as shown in the photograph, Fig. 2, and in the vertical section and plan of the assembled apparatus, Fig. 5. The mirror was adjusted roughly to bring the level rod into view, requiring a slight lateral reflection, as indicated in the general plan, Fig. 1; after which the upper section of the steam jacket was set in place on the lower, with an asbestos gasket between the two. A similar gasket was placed above, and an incandescent burner was suspended by means of its wire cord near the top of the air space. The jacket cover was then attached to the upper section by means of a swivel pipe coupling, so arranged that the cover could be swung aside to give ready access to the inner space as desired. The thermometer was inserted through the tube in the cover, its height being adjustable by means of the suspending cord passing through a cork in the top of the tube; so that the position of the mercury could be read with the telescope through the square aperture or window in front of the jacket. The mirror was then given a more refined adjustment so as to show a clearer view of the rod, after which the glass window slide was closed and the apparatus was allowed to stand over night to permit the two bars to assume identical temperatures.

In the earliest tests of the first season an effort was made to gain a wider range of temperature by cooling the jacket with ice water, but this plan was abandoned partly on account of leakage and also because atmospheric moisture condensed on the glass over the jacket window so as to prevent a clear vision in the reflected image of the target. It was found, however, that a lower initial temperature could be produced in the test bars by cooling off the laboratory over night. This was done by shutting off the steam heat and opening the windows for a time.

The test was usually started early in the morning. The observer, seated on a stool behind the telescope, noted the position of the bubble, set the target carefully by reflected vision, and read the thermometer, the electric current being turned on for only an instant so as to avoid affecting the temperature of the air space. After repeating the initial observations as a check and recording the readings, steam was turned on; first draining out the condensed steam from the supply main. The hose was attached, one length to the lower and another to the upper section of the jacket, as shown in Figs. 2, 3 and 5. The outlet pipes were run into the condensing pail or tank in the corner of the room, Fig. 1. The steam supply was turned on gradually, and simultaneous readings of the rod and thermometer were then taken at intervals of 15 minutes or so until the target and mercury became stationary. This usually required from 5 to 6 hours, and the observations were continued for an hour or so longer to make sure that the concrete bar was heated to the center. As the temperature of the air space increased the metal bar responded quickly, but the concrete bar expanded very slowly owing to the time required for the heat to penetrate its mass. This was clearly indicated by the rapid change in the target settings within the first hour, a maximum change of more than 0.8 ft. occurring with the copper bar in say 45 minutes, and 0.5 ft. or so with the steel bar in about the same interval of time. After passing this peak the rod differences gradually declined, due to the other end of the optical lever rising as the concrete bar expanded. These phenomena are clearly shown in Fig. 6, which is a typical diagram of temperature and rod differences for the tests of a bar of crushed stone concrete with both steel and copper standard bars. A casual examination of this diagram with its fairly smooth curves might, perhaps, lead one to think that the apparatus lacked delicacy, but the extreme sensitiveness of the optical device was clearly shown during the first year's tests when a small improvised boiler was used to supply steam to the jacket, a very slight reduction in the steam supply causing an immediate and marked drop in the rod reading. This was also observed on more than one occasion in the second series when the steam supply was cut off temporarily from the laboratory. However, the normal curve was quickly resumed when the steam was again supplied with full pressure. The final basis for the conclusion of an experiment was the sustained equality of mercury and target readings, the observations agreeing to the nearest 0.1° C. and 0.001 ft., respectively.

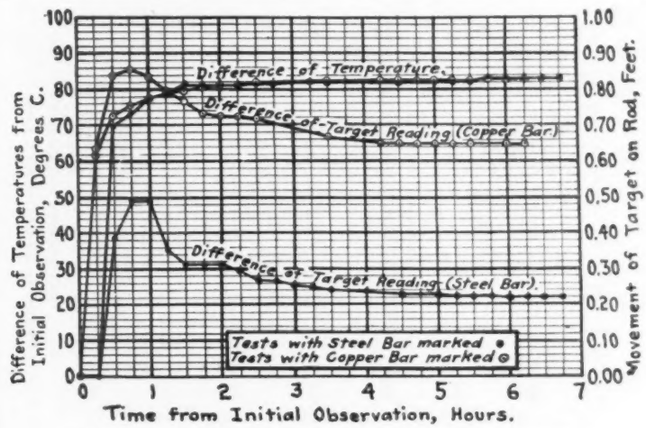

Difference of Temperatures from Initial Observation, Degrees C.
Movement of Target on Rod, Feet.
Difference of Temperature.
Difference of Target Reading (Copper Bar).
Difference of Target Reading (Steel Bar).
Tests with Steel Bar marked •
Tests with Copper Bar marked ⊙
Time from Initial Observation, Hours.

FIG. 6. TYPICAL EXPANSION DIAGRAM OF CONCRETE BAR.

REDUCTION OF DATA.—During the first year's tests only one calibration or standard bar, a 5-16-in. steel rod, was used, and the results were originally reduced with reference to an assumed value of the coefficient of expansion for that metal. However, at the beginning of the second season's tests, the coefficient of expansion of the steel bar was determined experimentally, as was that of a copper rod which it was thought best to use in the tests for the purpose of verification. Acknowledgment is made of the co-operation of the Department of Physics of Purdue University, both in determining these constants and in suggestions relating to the apparatus used in the experiments. The results of each set of experiments was consistent within itself, but the two sets were at first discordant as compared with each other. However, this discrepancy disappeared upon again reducing the first series with reference to the coefficient of expansion of the steel bar as determined experimentally.

The length of the standard metal bar was made such as to bring its top about on a level with the concrete bar when resting on its three supporting knobs. As the concrete bars were molded from 0.01 to 0.03 ft. longer than the 3.00 ft. originally planned for the second season's bars, it was necessary to make the calibration bars about 3.07 ft. in length. In the data it was assumed that the computed distance x, Fig. 5, represented the difference of expansion for a length just equal to that of the concrete bar proper. It is believed that this assumption is consistent with the degree of refinement maintained in reading the temperatures and also with the number of decimal places preserved in the final results given below.

RESULTS OF TESTS.—Each series included ten tests, of which five of the earlier and three of the later series were rejected because of obvious defects in the apparatus or for other sufficient cause. Of the five successful tests of the first series, four were on broken stone concrete bars and one on a bar of gravel concrete; and of the seven acceptable results in the later series, three were of gravel concrete, three of broken stone concrete, and one of a bar of the unbroken stone from the same quarry at Kankakee, Ill. The final results are shown in Tables I. and II.

TABLE I.—Coefficient of Expansion of 1 : 2 : 4 Broken Stone (Portland) Concrete.

Series.	Test.	Kind of stone.	Brand of cement.	Standard bar.	Coefficient of expansion (F.).
1st	No. 5	Bedford	Lehigh	Steel	0.0000052
1st	No. 6	Bedford	Lehigh	Steel	0.0000053
1st	No. 7	Bedford	Lehigh	Steel	0.0000053
1st	No. 10	Bedford	Lehigh	Steel	0.0000057
	Average of results of first series.....				0.0000054
2d	No. 2	Kankakee	Medusa	Steel	0.0000056
2d	No. 3	Kankakee	Medusa	Copper	0.0000054
2d	No. 8	Kankakee	Medusa	Steel	0.0000057
	Average of results of second series.....				0.0000056
	Average of entire series of results on broken stone concrete.....				0.0000055
	Coefficient of expansion, Kankakee limestone bar				0.0000056

TABLE II.—Coefficient of Expansion of 1 : 2 : 4 (or 1 : 5) Gravel (Portland) Concrete.

Series	Test.	Proportions.	Brand of cement.	Standard bar.	Coefficient of expansion (F.).
1st	No. 4	1 : 2 : 4	Lehigh	Steel	0.0000054
2d	No. 4	1 : 5	Medusa	Steel	0.0000055
2d	No. 7	1 : 5	Medusa	Copper	0.0000053
2d	No. 10	1 : 5	Medusa	Steel	0.0000052
	Average of results of second series.....				0.0000053
	Average of entire series on gravel concrete....				0.0000054

Grouping results still closer, we have for these experiments:

Coefficient of expansion of gravel concrete, 0.0000054 per degree F.
Coefficient of expansion of broken stone concrete, 0.0000055 per degree F.
Coefficient of expansion of limestone bar, 0.0000056 per degree F.

These results confirm the very natural supposition that the coefficient of expansion of broken stone concrete is not essentially different from that of the solid ledge from which the aggregate was crushed. This conclusion accords with the theory of an ideal concrete, in which the mortar exists in a thin film enveloping each fragment of the aggregate. It was intended to determine the coefficient of expansion of a bar made of 1 : 2 Portland cement mortar in the second series, but this test was inadvertently omitted. Considering the nature of the materials used in the manufacture of cement, however, it is more than likely that the result with such a bar would not differ greatly from those above summarized.

In conclusion, it may be said that while the scope of the experiments described in this paper is not such as to warrant a final judgment, still the results are believed to justify the tentative conclusion that the coefficient of expansion of concrete is about 0.0000055 per degree Fahrenheit. (This value is conveniently remembered as "five zeros fifty-five.")

GENERATORS AND TRANSFORMERS FOR THE BAY COUNTIES POWER CO., CALIFORNIA.

By E. Heitmann and Wm. Currie.*

Among the many engineering enterprises undertaken and completed within the last few years, the transmission system of the Bay Counties Power Co., of California, is for many reasons one of the most noteworthy, principally on account of the high potential adopted for the line voltage and the extreme distances to which the power is transmitted.

Since the transmission line itself has been adequately described in a former issue of Engineering News (Oct. 3, 1901), this paper will only contain a description of the generating units and the step-up transformers.

The service to which apparatus forming a part of such system is subjected is of necessity most severe, and great care and considerable experience is necessary for its proper selection. A discussion of the principal features to be considered will, therefore, be of general interest.

GENERATORS.

In general, the most important factors to be considered in selecting alternating current generators are high efficiencies at all loads, low heating, good regulation, thorough insulation and easy accessibility for quick repairs. While all of these features should receive due consideration, the regulation becomes of prime importance. With the exception of the drop due to the line itself, that of the generator is the greatest of all the apparatus used in an electric transmission; therefore the total regulation of the system largely depends upon it. Moreover, the load will always be quite inductive, and, at the best, it is difficult to obtain close regulation under such conditions.

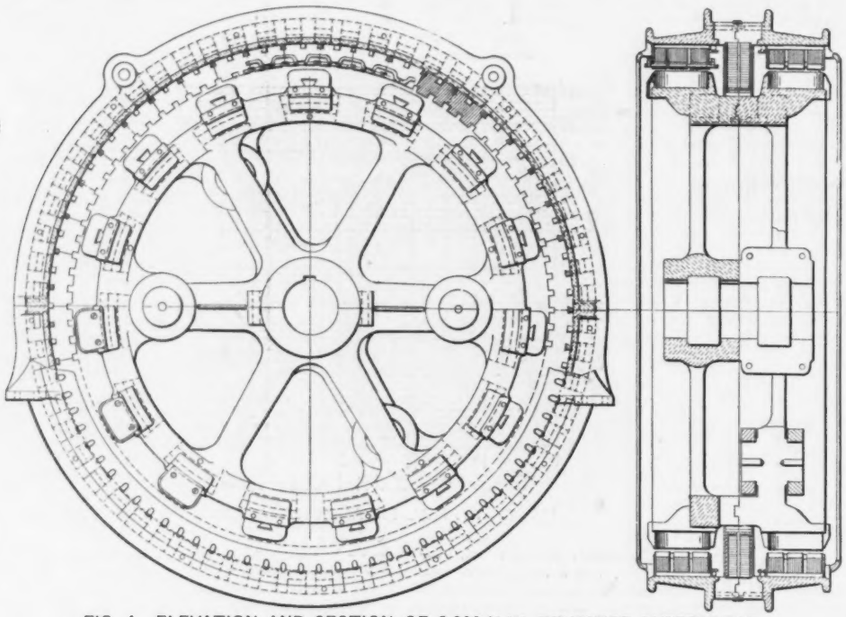


FIG. 1. ELEVATION AND SECTION OF 2,000-K-W. INDUCTOR-ALTERNATOR.

The two principal factors which determine the regulation of alternators are armature reaction and armature self-induction. It is desirable to keep the latter as small as possible in order to prevent an excessive rise in the voltage at low loads, due to the capacity current of the line. Hence it is important to not only have the regulation close but also to adopt a design which insures low armature self-induction.

The heating at normal loads should be low, since the deterioration of the insulation depends largely upon it and since this will also enable the generator to carry heavy overloads if necessary with perfect safety.

The parts liable to injury must be few and readily accessible. Mechanically the design must be such that the machine will withstand either shocks due to excessive overloads or a greatly increased speed, which may become possible with a breaking down of the governing apparatus, or a sudden decrease of load. The parts must also be limited in size and weight to permit of easy hauling over difficult roads and steep grades, common to mountainous districts.

The peripheral velocity of Pelton wheels is usually about one-half the spouting velocity of the water. Therefore where Pelton wheels operating under high heads are used as prime movers, it generally becomes necessary to adopt high speeds in order to keep the Pelton wheels within reasonable dimensions.

Hence, a design which can be used for high speeds and which embodies all the points enumerated, without becoming too bulky and costly, will at once recommend itself for this work.

The inductor-alternator possesses all these features to a marked degree. Its design and construction permits the use of extremely high peripheral speeds, effecting good ventilation and therefore low heating, and makes it possible to utilize armatures of large diameters and narrow widths, both of which are great aids in obtaining low self-induction and good regulation.

All of these features can best be illustrated by a description and discussion of one of the generating units installed. While the Bay Counties Co. have a number of different sizes, their characteristics are in all respects similar. A description of one generator will therefore suffice. The largest of these consists of a 2,000-K-W., 60 p. p. s., 2,200-volt, S. K. C. inductor alternator, direct-connected to a Pelton wheel operating at 240 R. P. M. These generators were built by the Stanley Elec. Mfg. Co., of Pittsfield, Mass.

MECHANICAL CONSTRUCTION.

The revolving element, or inductor, consists of four cast-steel quarters, Fig. 1. The two quarters, which form one-half of the inductor, are clamped together at the hub by means of heavy bolts and at the outer end of the spokes by means of rings shrunk on after installing. Bolts passing through the rim firmly unite the halves, which in addition are tongued and grooved on their inner surfaces.

Projections to which the laminations that form the pole pieces are attached are cast on the face

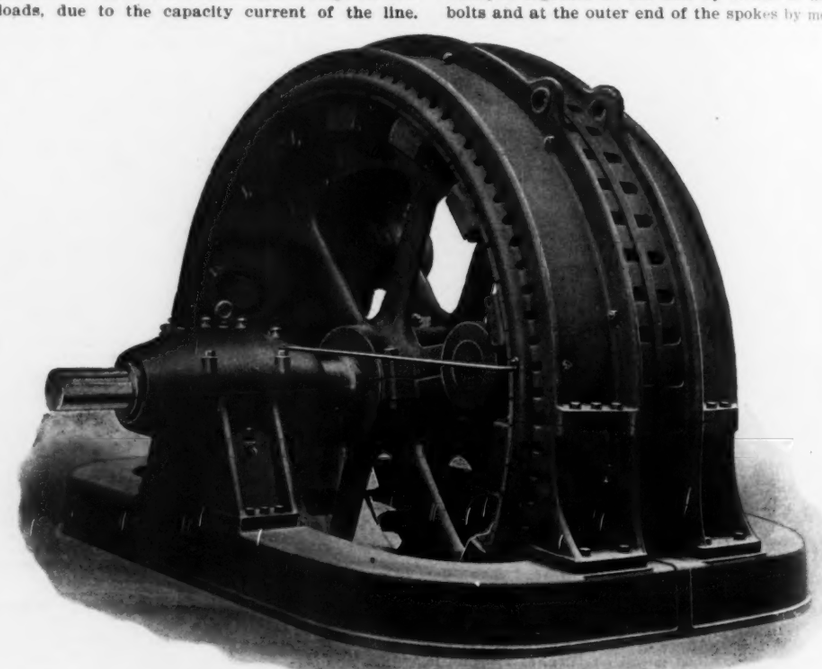


FIG. 2. PERSPECTIVE VIEW OF 2,000-K-W. IND UCTOR-ALTERNATOR FOR BAY COUNTIES POWER CO., CALIFORNIA.
The Stanley Electric Co., Pittsfield, Mass., Manufacturers.

*Engineers, the Stanley Electric Mfg. Co., Pittsfield, Mass.

of the rim. The laminations are held in place by means of keys and dovetails. The inductor rotates at a speed of nearly 10,000 ft. per minute; nevertheless, the fiber strains are such as to withstand an increase of 50% in speed with absolute safety. The inductor can be shipped in quarters if desired, one of these sections weighing approximately 13,000 lbs.

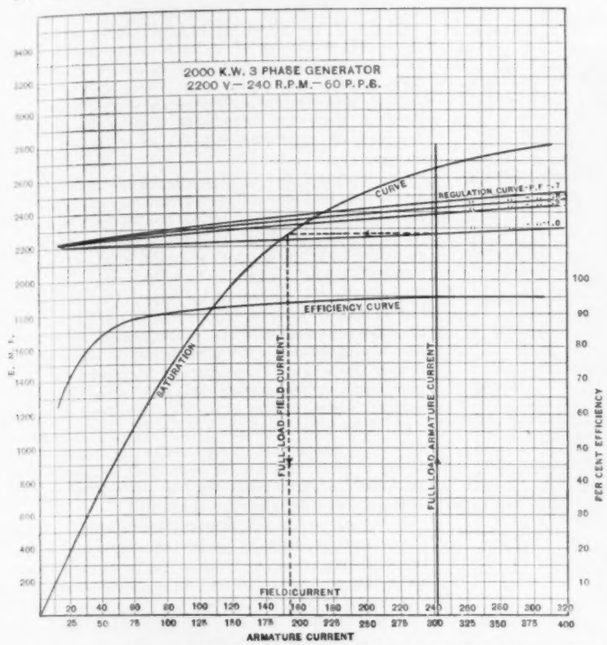


FIG. 3. CURVES SHOWING ELECTRICAL CHARACTERISTICS OF 2,000-K-W. INDUCTOR ALTERNATOR.

The pole punchings are shaped so as to cause a sine distribution of flux in the air gap. This, in connection with a low armature reaction and saturated teeth, insures a close approximation to a sine wave of E. M. F. at all loads. Curves of the wave form under two conditions are shown in Figs. 4 and 5.

All the metal is cut away between the polar projections, and since with this type of machine no exciting coils are placed around the poles, these act like vanes on a fan and a large volume of air is forced through the armature and around the field coil, insuring a perfect and efficient ventilation.

The armature consists of a cast-steel ring, ribbed as shown, to the inner surface of which the armature punchings are fastened by means of dovetails and keys, similar to the inductor punchings. This armature is also made up of four quarters, each of which weighs approximately 7,000 lbs. with the winding and punchings.

Four half-inch ventilating spaces are inserted at equal distances in the armature. Openings are punched into this iron midway between each dovetail which, when the iron is assembled, form ducts at right angles to the ventilating spaces. Holes are also cored in the outer casting at regular intervals around the periphery. Thus the entire construction permits of the best possible circulation of the air forced through by the inductor.

The armature winding is of the type known as a concentrated, two-coil per slot winding. Each coil consists of a few conductors, wound edgewise, with mica insulation between the layers. The coil is wrapped in a special insulation, treated with an insulating compound and thoroughly baked after winding. The coils can be removed by loosening several clamps, after which they can be dropped down between the poles and withdrawn. It is, therefore, possible to remove an armature coil without disturbing any other part of the machine.

The field coil consists of a single stationary coil, made up of copper strip, wound in two sections, with a wide ventilating duct between them. The whole is surrounded by a heavy brass bobbin, which not only insures perfect rigidity, but also, due to its secondary action, prevents any possible breaking down of the insulation when discharging the field. Being situated between the armature halves, its ventilation is thorough. Fig. 2 shows a view of the assembled machine.

ELECTRICAL DATA.

The principal electrical characteristics are given in Fig. 3. Of these the most important are the curves showing the regulation, especially on inductive loads. These were calculated from data obtained from the shop tests. The full load regulations are as follows:

For power factor	100%	— regulation is	3%
" " "	90%	— " "	8.2%
" " "	80%	— " "	11.0%
" " "	70%	— " "	11.4%

Fig. 4. No-Load Wave Form of 2,000-K-W. Inductor Alternator.

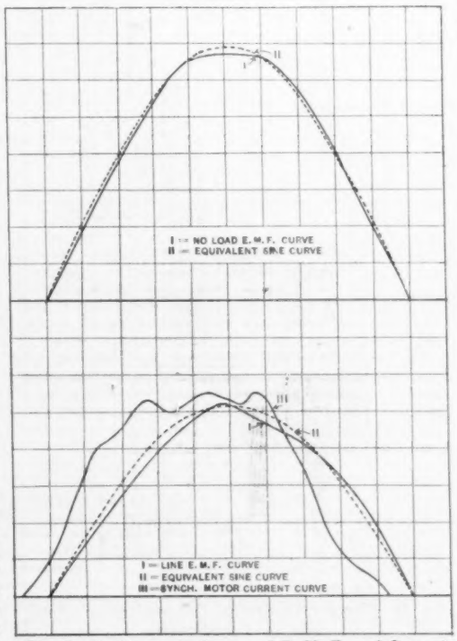


Fig. 5. Oscillograph Curves of E. M. F. and Current Taken at Oakland, Cal., 143 Miles from Power Station.

Thus, the regulation on low-power factor is extremely good, and the generator will have an inherent regulation of 10%, or better, for all loads likely to occur in such service.

The efficiencies, plotted in the same figure, were likewise calculated from shop tests, and are as follows:

125%	load	— efficiency	= 95.0%
100%	"	— "	= 94.75%
75%	"	— "	= 93.5%
50%	"	— "	= 92.0%
25%	"	— "	= 89.0%

The rise in temperature for continuous full load running is 35° C for all windings. The generator will also carry 125% load continuously, with a temperature rise of 45° C., and 150% load for four hours without dangerous heating.

The results show that the generator will meet all the electrical requirements in a more than satisfactory manner.

Fig. 4 gives a curve of E. M. F.'s showing the no-load wave form of this generator. It closely approximates a sine curve and retains this form with but slight modifications for all loads.

Fig. 5 gives curves of simultaneous E. M. F., and current taken with the oscillograph by Mr. E. E. Farmer at Piedmont Station, Oakland, which is the terminus of the 143 miles line of the Bay Counties Power Co. The curve of E. M. F. shows the impressed wave form, which is but very little distorted and shows the effect of the line of capacity in peaking the wave.

FIG. 10. PERSPECTIVE VIEW OF TRANSFORMER.

The current curve has extra waves at the top and is a little in advance. These extra waves were caused by the reaction of the synchronous motor into which the line was feeding. The motor is a three-phase 550-K-W. motor made by the General Electric Co. It was subsequently run as a generator, and the curve of free E. M. F. taken. This curve was of the same general form as the current curve. It is a striking example indicating the advisability of choosing a synchronous motor having the same wave form as the generator.

TRANSFORMERS.

While the same general features must be considered in selecting transformers as in selecting generators, and the question of regulation still remains an important factor in connection with transmission systems, the question of proper insulation undoubtedly becomes the one of greatest importance.

Fortunately, in designing transformers to overcome the difficulties inherent to insulating for extreme potentials, the other features, such as regulation, heating, etc., are directly benefited. Since the life of the insulation depends largely upon the temperature to which it is subjected, the method of dissipating the heat due to the copper and iron losses thus becomes second in importance.

In considering the losses, due regard should be paid, not only to those that will occur under normal conditions, but also to those that will occur under abnormal conditions, for instance, such as may be caused by periods of heavy overloads, repeated short circuits, or a failure in the auxiliary cooling apparatus. Any of these things may occur, and still the transformer should remain in service uninjured.

Oil, besides being a remarkably good insulator, is an extremely efficient cooling agent, inasmuch as a few degrees difference in temperature between the oil at the center and top of the transformer will cause the oil to circulate between the coils, thus carrying off the heat generated and dissipating it either by radiation from the surface of the tank or by some artificial means.

But for the fact that self-cooling transformers are impractical for large units, owing to their increased cost, a self-cooling, oil-insulated type

could be adopted. It, therefore, becomes necessary to select a type which is artificially cooled, either by air blast or water.

Since for high voltages it is desirable to retain the good insulating qualities of the oil, the air-blast method cannot be employed, and a water-cooled, oil-insulated transformer should be adopted for large units. Besides, where the motive power is derived from water, the installation and maintenance of the cooling appliances consisting of supply and drainage piping is extremely cheap, while the amount of water used is extremely small. Moreover, an increased water supply will permit of carrying heavy overloads for an extended time without injury to the installation.

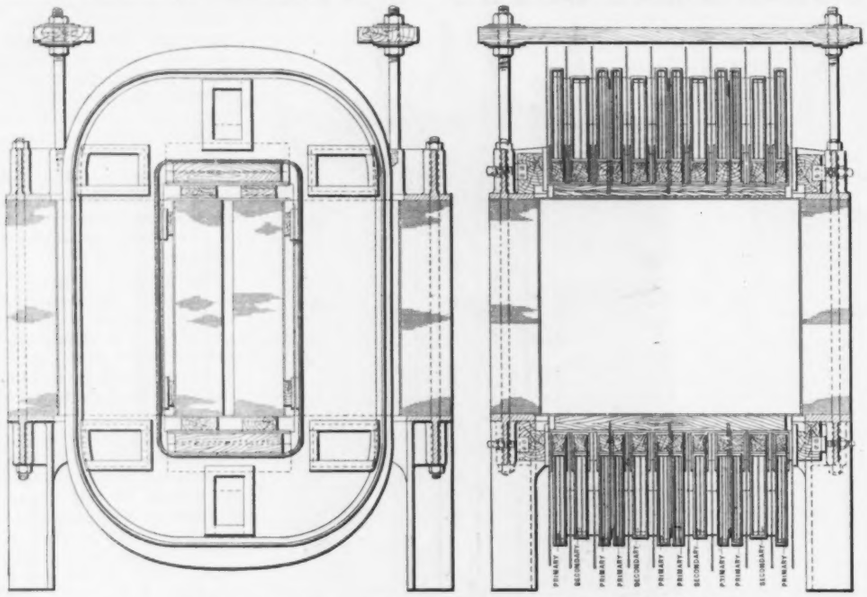


FIG. 7. SECTIONAL ELEVATIONS OF 700-K-W. TRANSFORMER.

Again, as pointed out before, the oil itself is a good cooling agent, thus making it possible to run this type of transformer for a considerable period without the use of artificial cooling, should the water supply fail.

The design must permit of a free circulation of the oil, at the same time insuring a perfectly rigid mechanical construction which will withstand the rough handling that is liable to occur in transit over railways and difficult roads, especially in mountainous districts.

An oil-insulated, water-cooled transformer, besides possessing all the essential features, has the additional advantage of lowest cost per kilowatt output and per kilowatt installed, making by far the most desirable type for high-tension, long-distance transmission systems.

The following description of the 700-K-W. 60 p. p. s. transformers, built by the Stanley Elec. Mfg. Co., and installed at the Colgate power-house of the Bay Counties Power Co., will fully illustrate the many advantages of this type of transformer.

These transformers at present step-up from a generator pressure of 2,300 volts to a line pressure of 40,000 volts. They are, however, designed for an ultimate line pressure of 60,000 volts, with taps brought out for 40,000 and 50,000 volts. The transformers themselves are wound on the low-tension side for 2,300 volts, and on the high-tension side for 34,675 volts, with taps brought out for 28,925 volts and 23,175 volts.

Each unit consists of a group of three transformers, as shown in Fig. 6, with delta connection on the low-tension side and star connection on the high-tension side. The neutrals of each group are connected on the high-tension side to a common ground, thus keeping the insulation strain within the limit of 35,000 volts.

Fig. 7 shows a cross-section of the transformer, the iron being built up so as to form a complete shell around the coils, and the construction being known as the shell type.

With such high potentials it is necessary to adopt a large number of coils in order to reduce the E. M. F. per coil. As shown, the high voltage winding is divided into 16 coils, thus reducing the maximum pressure per coil to 2,167 volts. Each coil consists of 73½ turns of strip copper wound with one turn per layer. The potential between adjacent layers is very low and the layers are separated by heavy insulation, securing perfect reliability from internal short circuits. The coils are assembled in groups of two, being separated by micanite slabs which extend above the strip, as shown, to prevent arcing between coils due to the existing difference of potential, insulation being filled in to bring the coils

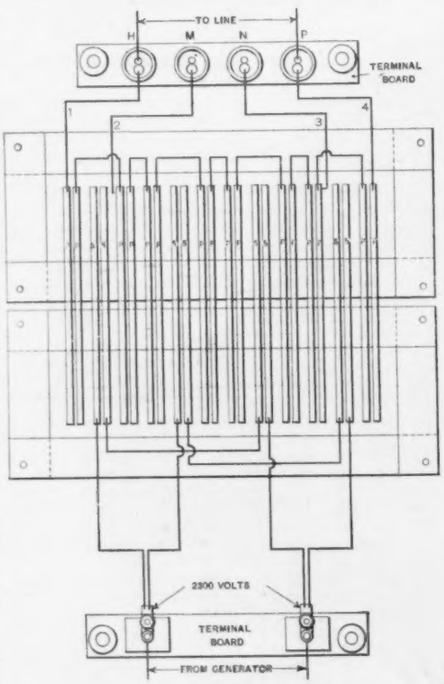


Fig. 8. Diagram Illustrating Connections of Windings in Transformer.

to a level with the micanite so that they may be readily taped together and insulated, thus forming one main coil. All the coils are connected in series, as shown in Fig. 8.

The low voltage winding is subdivided into eight coils. Each coil consists of 19½ turns of strip copper wound with one turn per layer, each turn consisting of three conductors in parallel. The coils are insulated and grouped in a similar manner to the secondary coils and connected as shown in Fig. 8.

With such a subdivision of the coils as above described, they can be made deep and narrow, thus insuring good radiation and low individual heating. With a few turns per coil, the leakage field surrounding the coil is small; thus the E. M. F. of self-induction of each individual coil is low and the regulation of the transformer is, therefore, vastly improved, especially on inductive loads. Also, with a low leakage field and the narrow laminated strip used, practically all the foucault or eddy currents are eliminated in the copper.

The high and low tension groups are sandwiched as shown, and are supported and held in place on the core by means of wood blocks and wedges. As is well understood, this thorough interleaving of the coils is necessary to obtain a proper interlinking of the magnetic flux with all windings. The groups are separated by mica slabs and spacing blocks, the slabs projecting beyond the coils to prevent arcing, and the construction being such as to permit of a free circulation of the oil between the coils. The material employed for insulating and supporting the coils from the core consists entirely of kiln-dried wood and mica, both absolutely indestructible at any temperature possible in these transformers under the worst conditions. The transformer is entirely supported by the cast-iron base and has no connection whatever with the sides of the case.

The main leads are brought up to wooden terminal boards, rigidly supported above the coils, these also having no connection with the case. Thus the design is thoroughly rigid and substantial, while at the same time the transformer may be removed from its case for inspection with the least expenditure of labor.

The cooling appliance, consisting of a few turns of brass pipe, as shown in Fig. 9, is supported from the sides in the upper part of the case. Through this pipe, there is constant flow of cool water, varying from 1½ to 2 gallons per minute according to the load. The oil as it circulates up between the coils, conducts the heat to the cool surface of the pipe coil, transmitting it to the water which carries it off. As stated before, the circulation of oil is automatic, being due to the difference in temperature of the oil at the center and surface.

The leads from the terminal boards for connection to the line are brought out through the cover in heavy porcelain insulators (see Figs. 9 and 10), the high voltage ones being specially designed with a large surface to prevent all possible leakage to the case.

All the iron parts of the transformer are earthed, the core being grounded to the base through the iron legs which support the transformer, and the base itself being thoroughly grounded, removing every possibility of accident to the attendant.

Fig. 11 gives some of the main electrical characteristics for this transformer, calculated from data obtained from shop tests.

The efficiencies given below, are remarkably good at all loads. They are:

98.6%	at	125%	load.
98.5%	"	100%	"
98.4%	"	75%	"
97.8%	"	50%	"
96.2%	"	25%	"

That the transformer more than meets all regulation requirements is shown by the following:

At full load and		100%	power factor,	regulation is	.7%
"	"	90%	"	"	1.9%
"	"	80%	"	"	2.4%
"	"	70%	"	"	2.6%

The rise in temperature of the oil after full load run of twenty-four hours did not exceed 35° C. above the air, while the transformer will carry 25% overload with a rise of 45° C., besides carrying larger overloads without dangerous heating.

The insulation tests given to the transformer were as follows:

75,000 volts between high-tension winding and iron for 1 minute.
75,000 volts between high-tension winding and low-tension winding for 1 minute.
37,000 volts between low-tension winding and iron for 1 minute.

LATE DEVELOPMENTS IN ORDNANCE AND ARMOR.*

By J. F. Meigs,† M. Soc. N. A. & M. E.

DEVELOPMENT OF ARMOR.—In the past ten years the developments in armor plate have consisted in, first, the introduction of nickel in the armor; second, the adoption of the super-carbonizing process invented by Mr. Harvey, and, third, the perfecting of this super-carbonizing process by Krupp. Parallel with these improvements in armor plate, whose tendency, or rather the tendency of the latter two, has been to produce armor of very hard outside face, the velocities of projectiles have advanced. From a purely rational point of view this would appear to be unreasonable, because hard armor is best attacked by heavy projectiles, which, if the size and weight of the gun remains constant, would mean a lowering of velocities. In other words, hard armor which may be cracked is best attacked by heavy projectiles, and comparatively soft armor by light, fast-flying shot.

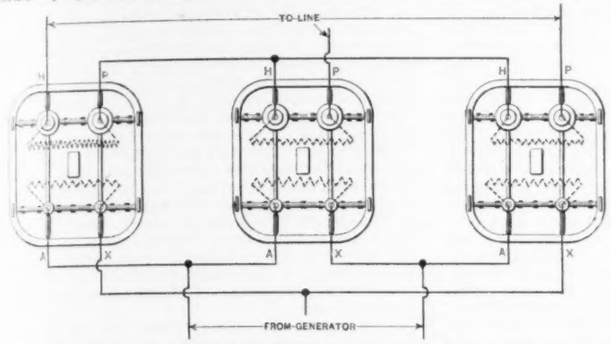


Fig. 6. Diagram Illustrating Connections of Group of Three Transformers in Colgate Power Station; Bay Counties Power Co.

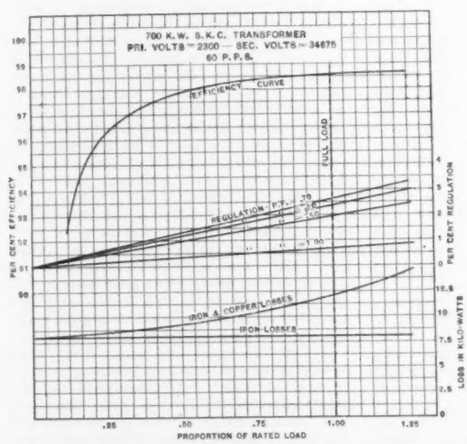


Fig. 11. Curves Showing Electrical Characteristics of 700-K-W. Transformer.

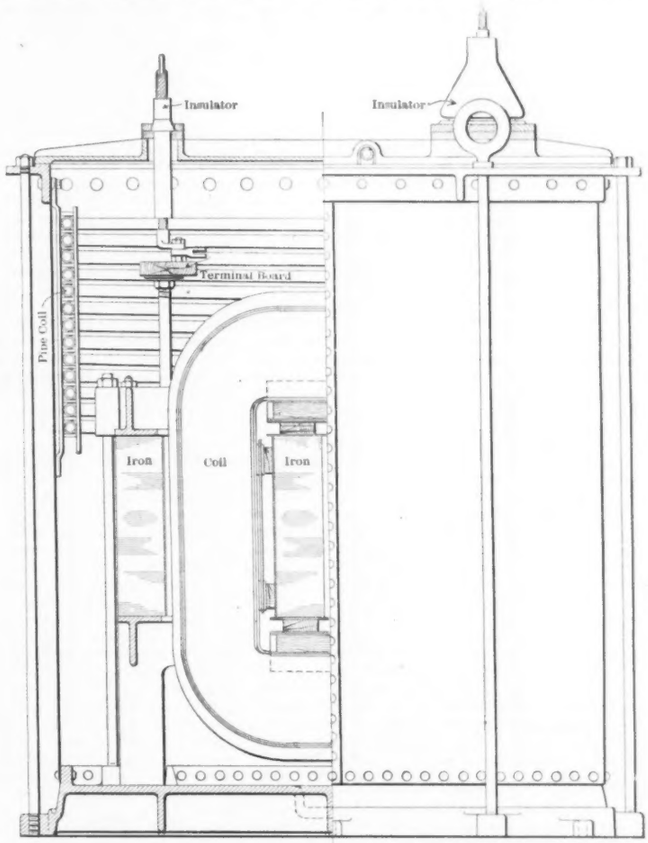


FIG. 9. HALF ELEVATION AND HALF VERTICAL SECTION OF TRANSFORMER, SHOWING COOLING APPARATUS.

In the ten years under review the advance in the resisting power of armor has been very material. The advance made by the introduction of nickel and by the adoption of the Harvey surface-hardening process, which were brought in at about the same time, added probably quite 25% to the power of armor plate of fixed thickness to resist penetration. The adoption of the Krupp process probably added another 10% to the resisting power of armor plate, and also added very materially to its power to resist cracking. It is perhaps not too much to say that the armor of to-day has 40 or 50% more power to resist penetration than that of ten or twelve years ago of the same thickness. Its power to resist cracking is very difficult to measure numerically. This power, however, is very greatly increased, as much because of the better methods of melting and forging large masses of steel, as for any other reasons. It seems now almost impossible to crack well-made armor plates under conditions approaching those usual in reception tests. Their surfaces are spalled for an inch or two depth, and the tough back of the plate is very resisting to cracking effect. In a word, when comparing the armored ship of to-day with the ship armored 12 years ago, say, with the same thickness, we find the former has an enormous superiority.

RAPIDITY OF FIRE.—The same degree of superiority is not found in the gun itself. The guns of a fixed caliber are longer and heavier than they were, and the powder is better than it was ten years ago, but, as stated, the gun itself, though shaped differently, has not improved from improvement in quality of material so much as armor plate. Ten years ago a 6-in. gun weighed about 11,000 lbs., while now it weighs from 17,000 to 18,000 lbs. The former gun gave barely 2,000 ft. with the brown powder then in use, while the latter gun, with its charge of smokeless powder, will give 3,000 ft. or more, and thereby its energy is more than doubled. This, however, it will be noted, is largely because the gun is heavier than the old 6-in. guns. The advantage which is most marked in the past decade in ship's guns, or, to use the more general term, in guns of position—that is, guns that are not moved from the place where they are set—is in rapidity of fire. Not many weeks since an English ship of war fired eight shots from a 6-in. gun in one minute, at a range of about 1,500 yds., at a target 15 ft. high, and struck it every time. Such a feat a few years since would have been thought impossible, and, in fact, many people with whom I have conversed will not believe what I have stated to be a fact, but the reports that I read of it in the newspapers, which, of course, are available to anybody, are of such a nature that I myself believe its truth. No doubt the ammunition was close by, or it is possible that the ammunition supply arrangements may have been extremely good, and that the ammunition may have been brought from the magazine. This is unlikely, however, and in the statement that I have seen, this is not said to have been the case. The actual trial of how many complete rounds of ammunition can be delivered to each gun in a ship would appear to constitute as important a datum regarding her efficiency as her record on the measured mile. It would depend, of course, upon her structural arrangements and upon the skill of the ammunition passers.

No doubt, also, the ship's course was carefully selected in such a way as to blow the smoke away from the gun, for, although powder is now called smokeless, the heated gases coming from the gun render it impossible to aim properly until they have blown away, and, if blowing towards the firer, they would hurt his eyes so that he could not make good practice. We hear, also, of guns, whose projectiles weigh 350 lbs. being fired three or four times a minute. These things are no doubt true, in at least a limited degree, and constitute a very marked advance in gunnery, for, while it would not be possible to fire a 6-in. gun many minutes at eight rounds per minute, both because the crew would become exhausted and because the gun and other parts would heat, yet the fact that this can be done for a short time, when it becomes necessary, is a matter of great consequence. It appears that this end has been reached, principally, if not solely, by putting it into the hands of one man—namely, the firer, to do everything that is required to aim and fire the gun, without moving and without taking his eyes from the line of sight. He simply keeps the gun aimed all the time, and fires it whenever it is loaded and as quickly as it is loaded. The adoption of measures of safety whereby he, standing half way from the breech to the trunnion of the gun, and with his back to the breech block, cannot fire the gun unless the breech is properly closed and the man handling it out of the way, are details of manufacture which have been mastered.

EFFECTIVE RANGE.—While, of course, it is very difficult to say at what range modern ships will fight, yet it would appear that this matter must be settled before any conclusions can be reached with regard to the kind of guns to be placed in ships. For example, if the old "Pensacola," having ten smooth-bore 9-in. guns on her broadside, can choose her range, she is more than a match for the modern "Atianta," of equal tonnage, carrying three 6-in. and two 8-in. breech-loading guns on her broadside. The ship that can control range can outclass the other. It is necessary to determine to what range ships will usually come before determining upon their batteries and armor.

There is much difference of opinion in regard to the range at which the modern gun is effective. Possibly this comes from a neglect to appreciate the circumstances of the use of the gun, rather than the accuracy of the gun itself. The gun is itself very accurate, but the circumstances of its use are much less so. The changes in velocity, due to changes in powder, cause some variation in the range of the gun, but the greatest difficulty consists in the absence of correct knowledge of the range, and, in guns in ships, in the continual motion of the ship—both the rolling motion and the swing, when the ship is turning through an angle. My impression is that those who have witnessed a good deal of firing from guns in coast fortifications think that a ship would be in great danger from the guns of a fort in direct fire at 8,000 or 9,000 yds., and I assume that this presupposes that the range is accurately known, as it usually may be in a fort. I should think, however, that so great accuracy would be attained only when the firing is very deliberate, and when such elements as the muzzle velocity due to the powder in use are accurately known. In a ship gun, where the range is rarely accurately known, and where the ship is usually moving, accurate practice cannot be made at so great a distance as 8,000 yds. I think that most naval

*A paper read at the ninth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, Nov. 14 and 15, 1901.

†Ordnance engineer, Bethlehem Iron Co., South Bethlehem, Pa.

officers believe that with their guns, and in reasonably smooth water, they can make fair practice at 3,000 or 4,000 yds. My own belief is that this is too great an estimate. At 3,000 yds. range a target 15 ft. high, when a gun is rolling at an angular rate of 1° per second, which is a fair rate only, the prolongation of the line of sight of the gun would sweep across the freeboard of a ship 15 ft. high, which would include all the vulnerable part of the ship, in somewhat less than one-tenth of a second. This a period of time too small to be appreciated by a man's nerves, and, indeed, the accuracy of operation of the firing apparatus of the gun can hardly come within this limit.

MUZZLE VELOCITY.—It is usual to assert that naval guns stand in greater need of high velocity than land guns, in order that the trajectory may be flatter and the gunner indepedent of the range at great distances. At present, for practical purposes, the trajectory is a straight line—having regard to the height of the broadside of the ship—for about 1,500 yds. in length. By insisting, however, upon what is now known as "power" in guns—that is, the use of elongated and fast-flying projectiles rather than those which approach a rounded form and move with lower velocity, much is necessarily lost in smashing effect. The shell charges become smaller and the mine effect of the shell becomes less, and the damage to constructions that are hit becomes less. The shot of the old-fashioned 9-in. smooth-bore guns weighed 90 lbs., while that of the modern 6-in. rifle weighs 100 lbs. For anything that it can penetrate the former constitutes a more dangerous projectile than the latter. Against the upper works of vessels the old round shot is by no means to be despised. This all arouses the question of what caliber of gun the designer of a warship will put in. He has a certain weight to put into battery, and the question comes to him at once: Having 100 tons to dispose in guns and gun carriages, shall it be put in so many 8-in. guns or in so many 6-in. guns? Roughly, the weights of guns vary with the cube of the calibers, and for every 8-in. gun you can have eight 4-in. As the 4-in. gun fires a good deal faster than the 8-in., the weight of metal and of bursting charge thrown by the battery of light guns would considerably exceed that thrown by the heavier ones. The weight of a single discharge from a battery of fixed weight, of any caliber, would remain about the same, of course. These, it seems, are the great tactical questions in regard to guns: First, having a fixed system of guns—that is, having guns of differing calibers in which the dimensions are about proportional to the calibers, what size guns shall we use; and, second, there is the other question: Is the system right? That is, should 8-in. guns weigh what they do, or should they weigh more or less; or, to put it in another way, are we satisfied with present weights of guns, or do we want more velocity in a gun of fixed caliber, and are we willing to accept the increased weight that must be given to the gun to get this.

Much discussion is going on now in regard to the substitution of 7-in. and 7.5-in. guns for 6-in. guns on the broadside of battleships, and, while everybody must be desirous of increasing to the utmost the size of the guns, and, consequently, their destructive effect, it must be remembered that this inevitably makes the weight carried heavier, and in certian cases limits the speed of firing. It has been generally asserted that guns cease to be rapid-fire when increased beyond 6 ins. in caliber. Even 6-in. guns must have their cartridges separate from the projectile, and, as the projectile weighs 100 lbs., it is about all that one man wants to put into a gun quickly when standing on the deck of a rolling ship.

ARRANGEMENT OF TURRETS.—Another matter of much interest just now, particularly in this country, is the disposition of the turrets in battleships. I had the opportunity last summer to go over the battleships "Alabama," "Kearsarge," and "Massachusetts," when lying in Newport harbor. It is not necessary here to describe the batteries of these three ships, as they are all known to you, but there was perhaps no sentiment aroused within me more clearly defined than that of sympathy with the various officers and boards that have been called upon from time to time to pass upon the batteries of these ships. Volumes could be written upon the subject, and no one can reach a conclusion without first forming a clear idea of what sort of combat these ships are most likely to be engaged in. As we do not know what this will be, it seems that no one can dogmatize on the subject, and that all that can be done is that the matter shall be determined according to our lights, and that thereafter we should hope for the best. In passing, however, it may be noted that American ships always, from the first, have been very heavily gunned, and that again and again this has been shown, when the time of trial arrived, to be of vital importance.

There are many minor improvements which have been introduced in the use of guns, as, for instance, the almost general adoption of telescopic sights, which give greater accuracy of fire, the use of electric firing, which fires the gun more quickly when the sights are on, the use of automatic ejectors for the primers, and improvements in fuses. Also, high explosives have come to be used very generally in shell. These explosives are usually of the picric acid order, but have not yet attained much acceptance in this country. Many believe that they are quite as safe in shells as the old black powder, and, as they certainly break shells into a larger number of parts than the older explosives, it would appear that they are certain to be adopted in time. Also caps have been used on the point of armor-piercing projectiles, and these are becoming universal. Many theories are advanced as to why they help a shot through an armor plate, but of the fact that they do so help it, there is no doubt whatever. It is said that they are least effective in oblique fire, and, while this may be so, it is yet a thing very hard to demonstrate, as the penetration of all armor-piercing projectiles falls off very quickly when the shell does not strike fairly point first. The cause of this seems to be largely that the whole back end of the projectile, upon striking a plate obliquely is wrenched off, and the very second that a projectile, when striking an armor plate, begins to go to pieces, that second it is done for and its chance of doing any material harm to the armor becomes nil.

SMOKELESS POWDER.—In no respect, perhaps, has greater improvement in gunnery been made in the last ten years than in the practically universal adoption of smokeless powder. At present, the pure nitro-cellulose powder is generally held to be much the best. Though smokelessness is usually put forward as the great advantage of the modern powder, yet the absence of solid residue in the products of combustion would appear to be the real gain in this regard. In the old powders about 40% of solid residue was projected from the gun as uselessly as though its weight was in sand, while in the modern powder all or nearly all the charge turns into gas and helps to propel the projectile. On the other hand, the gas of the modern powder, particularly where much nitroglycerine is used in making it up, as is the case in cordite, for example, is of very high temperature and scores and gutters the gun very badly. This is much less so with the nitro-cellulose variety, and with the latter, where moderate pressures are used—say, of 34,000 or 35,000 lbs., the scoring of the gun is not a very serious matter. The scoring of steel by hot powder gas is a most extraordinary phenomenon. If there is ever so little a channel through which the gas can escape the steel is washed out and disappears in a most wonderful way. As, however, the propelling power of powder depends upon the amount of gas given off and upon the temperature to which it is heated, it is desirable, of course, to use as high a temperature as we can. In other words, if the scoring and guttering of the gas could be controlled, the hotter it is the greater the velocity attained would be. As a matter of fact, however, when high pressures, say, 40,000 to 50,000 lbs., are reached, the destructive power of the gas becomes very great. When the new powders came in first it was thought that a charge of one-fourth or one-third the weight of the projectile would be ample to give all the velocity that would be needed, but, owing to the desire to attain very high velocities (3,000 ft. and upwards), the weights of charges have been creeping up of late until now, in some guns, they approach one-half the weight of the projectile, which is the figure at which they stood roughly in the days of brown or cocoa powder.

It need hardly be pointed out here how important a matter this is as controlling the sizes of magazines of ships. Indeed, in some classes of artillery, as for instance in field artillery, where weight is of vital importance, there are many who believe that some form of nitroglycerine powder may still be used, as it is with shoulder guns.

QUALITY OF STEEL.—A word may now be said in regard to the improvements in the quality of steel in guns, and whatever is said about this may apply, it is obvious, to shafting. Ten or twelve years since or thereabouts, the tube of a large gun or a large piece of shafting which showed 40,000 lbs. elastic strength was considered something rather out of the common; nowadays it is not at all unusual to be able to secure 60,000 lbs. elastic strength in the same forging. This could be attained with about 16% elongation. Indeed, up to guns of about 5-in. caliber, the tube and jacket of which constitute pretty reasonably sized forgings, qualities as high as 70,000 lbs. elastic strength, with 16% elongation, and about 130,000 lbs. ultimate strength, have been reached at Bethlehem. Nor is there any reason to anticipate that this material is any less safe to use than the softer material. Indeed, all the evidence goes the other way. It would not, perhaps, be desirable to reduce a gun's thickness of wall very materially in case this stronger material is used, but rather to consider the gained strength as so much surety against disastrous accidents. Indeed it would be impossible to materially reduce the weights of guns without increasing that of their carriages, as with a lighter gun the recoil would become much more violent and harder to control. It would be very easy, if desired by ship constructors, to give the gun a larger base upon which to stand and to increase the length of recoil in many instances. As a striking example of this latter, it may be mentioned that modern quick-fire field artillery use a 3-in. gun 90 ins. long, employing a recoil of 40 or 50 ins.—that is, the gun recoils half of its own length. Of course it might be entirely undesirable to let a ship gun recoil through anything like such a distance as this, but there is nothing impossible about it if desired. Possibly one of the most striking changes made in gunnery in the last few years has been in the field artillery. By means of the long recoil stated, and by the adoption of the so-called spade at the end of the trail, which spade enters the ground, these guns have become capable of a very rapid rate of fire and have been fired 10 and even 20 times within a minute. The men handling them sit on seats fast to the trail, and anyone who saw the field guns of a few years since, when in action, will realize what a revolution this means.

CALIBER OF GUNS.—It used to be accepted as a sort of an axiom in ship design that the armor should be so distributed and the vulnerable parts of a ship so protected that no one shot could destroy her. This has led, in view of the heavy turret guns carried by ships, to the heavy side armor and heavy armor on the turret and barbette. I think a study of naval history will bear me out in the statement that the resistance of ships has been overcome nearly always by silencing the battery and not by destroying the ship. If this is so, a ship should carry large bored guns of respectable penetrating and mine-power, and their magazines and ammunition supply arrangement should be such that they could be served at maximum rate. Roughly, if the systems of the guns are the same—that is, if the guns are of the same dimensions, when stated in calibers, then for every 12-in. gun we may have 27 4-in. guns, and as the rate of fire of each 4-in. gun, owing to the size of which the ammunition could be handled at the gun—providing it could be brought there from the magazine—is quite five times that of the 12-in., it becomes apparent how much total metal and bursting charge is sacrificed for the heavy turret gun. Suppose a ship, instead of, say, four 12-in. guns and four 8-in. and 16 6-in. guns, should carry about 170 4-in. guns or 86 4-in. on her broadside, or a total of 56 6-in., say. Which would be the better ship? Of course this parallel may be reasonably combated, but to me it means a great deal. If it be true that ships are overcome by their batteries being silenced—that is, by their men being driven from the guns—then the number of shots fired becomes a question of great importance.

At the present time it may be said that the principal guns of battleships are in turrets, usually in pairs, and are of 12-in. caliber. The thickness of the turret armor is 12 ins. usually, or less. The so-called secondary batteries of battleships are composed of 6-in. guns, which are in broadside, and are often isolated by transverse armor and armor to their rears, which renders it unlikely that more than one of them could be silenced by the bursting of a single shell. These 6-in. guns are for the most part behind 5-in. and 6-in. armor. In other words, as the actual velocities for turret guns now afloat do not exceed an average of 2,300 ft., the turret guns of contending battleships can destroy each other only when within 600 or 700 yds. range, and the guns of their secondary batteries, the ruling velocities of these being put at 2,300 or 2,400 ft., when within 1,000 yds. range. More powerful guns of both classes are now being built and mounted, but a great number of 6-in. and 12-in. guns now in use would come within the approximate rule just laid down. Thus we may fix the fighting range of battleships at 1,000 yds. There appears to be no disposition to increase the caliber of the 12-in. turret guns forming the main battery of battleships, though there is considerable movement looking toward making these guns longer and heavier, and, consequently, imparting to their projectiles higher velocities than those now ruling. As respects the 6-in. guns forming the secondary batteries, naval opinion is entirely at variance. In this country there are many who would substitute for the 6-in. guns 8-in. guns, and others who would substitute 7-in. guns, while in England the bulk of opinion, so far as discoverable from published accounts, is in favor of a 7.5-in. gun, whose projectile weighs 200 lbs. To this 200-lb. projectile would be imparted a velocity of 3,000 ft. or more, so that the 7.5-in. gun in England is a very large and very powerful weapon. The 7-in. gun proposed in this country and developed by our Navy Department, requires a 160-lb. projectile, and to the projectile is imparted a velocity of 3,000 ft. or more. There is some disposition on the continent of Europe to use lighter guns in turrets than those of 12-in. caliber, which will weigh from 45 to 50 tons; but in this country and in England the 12-in. gun seems to be pretty strongly held to. The secondary battery guns, however, as stated, are quite unsettled. Besides the 12-in. and 6-in. guns, protected, respectively, by 12-in. and 6-in. armor, battleships carry a large number of 3-in. 15-pdr. guns, having a high velocity and having very little protection. The large armored cruisers, which, in their elements of offence and defence, now approach battleships very closely, carry somewhat smaller guns than the latter and their armor is accordingly reduced. When we come to the smaller vessels of all classes, the protection afforded the batteries is usually very little, besides the gun shields, and the side and other armor, of course, is also materially reduced.

There are many reasons why the battleship, armed with 12-in. guns in her turrets and 8-in. guns on her broadsides, which is the favorite battery with those who would push the weight of battery very far, would have great advantages over battleships carrying only 6-in. guns in their secondary batteries; but, if the muzzle velocities of the 8-in. guns be equal to those of the 6-in. guns, and the total weights of battery are about the same, the number of 8-in. guns would be one-half that of the 6-in. and the rate of fire of the 8-in., as compared with the 6-in., will be very materially reduced—it is, perhaps, not too much

to say that it will be reduced by one-half. The 6-in. gun can be man-handled—that is to say, the shot can be handled by one man and all operations performed with ease, without the use of mechanical apparatus. There are many devices for simplifying the handling of projectiles and getting them into the gun, but it must always remain that the weight of the 8-in. shot—now 250 lbs.—will remain a serious impediment in the way of handling the gun rapidly.

Very little has been said about the numerous small caliber guns, such as 6 and 3 and 1-pdrs. These are now usually either fully automatic or semi-automatic in character, and occupy an important field in certain classes of naval warfare, such as the repulse of torpedo boats, the protection of mine fields, and in landing operations. As regards a naval landing gun, it has been a rule to regard these in much the same way that the field gun on shore is regarded—that is, it is a question in which mobility is of great importance. Naval landing guns, however, must be materially lighter than the field gun of the army, which weighs, on its carriage and without any ammunition, about 2,000 lbs. This is obviously too heavy to be drawn over rough roads by men, and the naval landing gun, itself weighing some 500 or 600 lbs., usually weighs, with its carriage complete, about 1,200 or 1,500 lbs., and is of approximately 3-in. bore. The 6 and 3 and 1-pdrs. are usually conveniently disposed on the rail of a ship and in her tops, and are suited only to the attack of unprotected parts. The 1-pdrs. and 3-pdrs. are also sometimes used as landing guns.

SUMMARY.—To summarize results it may be said that, in the past ten years, by the use of better mixtures, by improved heat treatment, and by very marked improvement in face hardening, the power of armor of a fixed thickness to resist penetration has been increased about 40%, while its power to resist cracking has been increased in even greater degree. This has been taken advantage of in large measure in a reduction of the thickness of armor plate on a ship's side. The total weight of armor carried is not less than formerly, and indeed it is perhaps greater than it was, but it is more spread out, and, while the protection on the vital parts is as good and perhaps better than it was, there is now some weight in armor left to cover parts that formerly were without protection.

Gun steel also—and in speaking of gun steel we may include the steel for shafting as well—has been materially improved in the period under review. The shafting steel now going into ships is very much stronger than that which was used ten years ago. It is, indeed, perhaps quite 70 or 80% stronger than the former material. The advance in gun steel has not been so marked, because ten years ago the purchasers of gun steel wanted an elastic strength of about 40,000 lbs., whereas only 28,000 or 30,000 lbs. was asked for in shafting. Now they both run 50,000 lbs., or even more. These very desirable and very material advances in quality have been rendered possible by the adoption of more satisfactory mixtures in the melting furnaces, and by more skilful heat treatment. They have not, however, been accomplished without much experimentation and the expenditure of a great deal of thought and money. The noted advance in the strength of gun steel has not been followed by a reduction in the thickness of gun's walls. Indeed the gun's thickness is rather greater perhaps than it was, and the increased strength serves only as an additional guarantee against disaster.

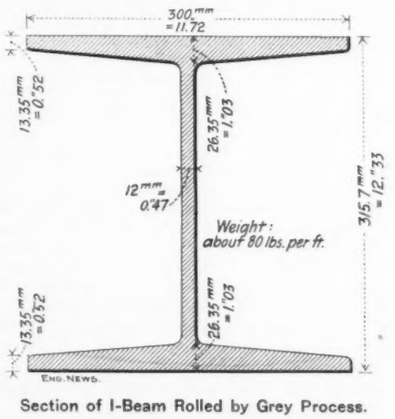
When we come to what may be called the tactical aspects of guns and armor, we find also material changes. The quality of the gun steel and of the armor, as is stated above, has advanced by perhaps 40%, and full advantage has been taken of this in design. The modifications in design which have come about have been numerous. The armor is more distributed. It has come to be recognized that unprotected guns have no chance, and that 6-in. and 12-in. guns should be protected, respectively, by 6-in. and 12-in. armor. It should be noted that this means, if battleships are to penetrate each other, that ships must approach within 1,000 yds. range in combat. This brings us back to the fighting range of old wooden ships, very nearly, for they had to approach within about 600 or 700 yds.; and, when you consider that a battleship's 6-in. guns must have normal impact to perforate the armor protecting the 6-in. guns of their opponents at 800 or 1,000 yds., it may be said that the fighting range of ships has not so very materially altered in the past hundred years. What is here said may perhaps be combated, but, as 2,200 ft. velocity in a 6-in. projectile will not, even with normal impact, carry it through 6-in. armor, nor will 2,000 ft. carry a 12-in. projectile through 12-in. armor under like circumstances, it follows, when the vast preponderance of oblique impacts is considered, that ships must fight within 1,000 yds.

Finally, in closing, I want to bring forward, in order to more definitely determine the coming range of naval combat, the fact that there is one of its ruling factors which remains constant for all time. This is, the accuracy and delicacy of the firer's eyes and nerves. If a man can appreciate four intervals in a second, and if the firing apparatus put into his hands is instantaneous in action, he can hit a ship 15 ft. high, at a range of about 1,000 yds., when his own gun is swinging, in rolling, at an angular rate of 1° per second. This consideration, of course, remains fixed for all time. Another important consideration is what is usually called the "danger" space. With medium calibers, with 2,000 ft. velocity, the danger space is 1,100 yds. That is to say, the gun is independent of the range, as the trajectory is so nearly flat at that distance. The new guns now coming along, having 3,000 ft. velocity, have a greater danger space with existing targets, and are therefore independent of the range up to 1,300 or 1,400 yds.

Whether it is better to use a 7-in. or 7.5-in. gun on the same weight as the 50-caliber 6-in. gun, that is, about 18,000 lbs., in the secondary battery of battleships, is one of the pressing questions of the day. If the 7-in. or 7.5-in. gun has its weight increased proportionately it will, of course, be better than the 6-in., except that its rate of fire will be less from the weight of its shot, but, if we take the larger calibered gun and accept a somewhat lower velocity, while using the heavier and larger shot and the same total weight in the gun and carriage, it may well be argued that the larger gun is the better. On the other hand, high velocity gives always an independence of the range at greater distances, and gives always greater penetration. The designer of naval ships is therefore on the horns of a dilemma with regard to the battery of the ship, as indeed he must be with regard to pretty much all of her elements, and he must be guided by judgment and by a careful balancing of conditions, so that, upon the whole, and in the circumstances most likely to occur, the ship he produces will be able to give a good account of herself.

A NEW PROCESS FOR ROLLING STRUCTURAL STEEL SHAPES.

For some time past a mill has been in operation at Differdange, in the Grand-duchy of Luxemburg, which, by a process invented by an American, Mr. Henry Grey, produces I-beams of proportions that it has hitherto been considered impossible to roll. A piece of an I-beam 12 ins. deep rolled by this process has been received at the American offices of the company controlling the invention, the American Universal Mill Co., of 76



Section of I-Beam Rolled by Grey Process.

William St., New York. The accompanying sketch shows the cross-section of this beam and gives its principal dimensions. The portion of beam shows on inspection no sign of imperfection, the extremities of the flanges are as sound as the web; it is said that the material is practically homogeneous in composition throughout the section.

The method of rolling comprises essentially a set of rolls with axes placed parallel to the web and working the inner profile of the beam, and a second set of rolls with axes normal to the web which work the outer faces of the flanges. The speeds of the two sets of rolls and their diameters are so related as to produce homogeneity of structure. A feature of commercial importance is the adjustable support of the rolls, permitting, for instance, a variation in weight by increase of flanges alone, or by increase of flanges and web in any specified proportion and that without changing rolls.

The process may, it is evident, be applied equally well to the rolling of channels as well as I-beams, and channel-shapes could be produced by it of proportions as unusual as those of the section shown. No attempt has as yet been made, however, to roll such channels, a list of sections rolled by the Grey process at the Differdange works showing only I-sections.

An extensive field is open for the utilization in building and engineering construction of I-beams having proportions such as this process makes possible. Columns made of a single I-beam, already quite popular with architects and engineers engaged in steel-cage building work, will doubtlessly be used very widely when the Grey shapes become commercially available. An even greater use might be anticipated in beamwork. The wider flanges and the lighter sections made possible would enable great economy to be attained in many cases over present construction; for beams of long span heavier sections of a given size, with the excess in the flanges instead of, as at present, in the web, would prove convenient and economical.

In another issue, in the near future, we expect to present further details of the Grey method of rolling, and of the mechanical features connected with the machinery employed.

METHOD OF CROSSING MARSHY GROUND ON THE DETROIT & MILWAUKEE R. R., IN 1877.

The late sinking of part of the roadway of the Chicago, Indianapolis & Louisville R. R., in Lake Co., Ill., and the difficulty encountered in filling up the hole, as related in our issue of Oct. 31, recalls a similar experience on the Detroit & Milwaukee R. R. some years ago. The story was told in Engineering News for Sept. 15, 1877, but will be new to many of our present readers.

This railway ran across the State of Michigan, from Grand Haven to Detroit, a distance of 189 miles. At Grand Haven, the only available ground for the railway terminus, on the south bank of the river, was a broad and deep marsh; and to pile and fill this ground was too expensive an undertaking for the railway company of that date.

In this emergency, Mr. George Masson, then Chief Engineer of the company, devised the following method for overcoming the difficulty. Grand Haven was a town of saw-mills and slabs were abundant; and with these slabs and sand from the sand dunes north of the river the work was done. Slab-rafts were first built, and on these were laid the ties and rails; on this improvised track sand was hauled out and dumped until not only a solid roadway was secured, but 13 acres of the marsh were finally reclaimed and utilized for yard and shop purposes.

Six miles east of Grand Rapids a similar problem presented itself to Mr. Masson, and was also solved with slabs and sand. This was a "sink-hole," 2,600 ft. long and 60 ft. deep to clay, occurring on the summit of a grade. The contents of this hole were made up of water and a soft muck; and a previous engineer had failed in an attempt to fill it, and for twenty years the road had been carried around the bog. Mr. Masson laid down and firmly bound together slabs and "edging," until a raft was made 10 ft. thick. This raft supported his sand-train, and sand was dumped into the hole until a solid roadway was secured. The greatest difficulty met with was to counteract the tipping tendency of the raft under the weight of the train and the pressure of the sand; but this was successfully accomplished. The work was done in three months, with one train and 75 men, at a total cost of about $10,000.

It is interesting to note that the then superintendent of the Detroit & Milwaukee R. R. was "the young but efficient S. R. Callaway," late President of the New York Central & Hudson River R. R. Co., and now President of the American Locomotive Co.

THE U. S. ENGINEER SCHOOL recently established at Washington, D. C., will take up the four following branches of instruction, according to the regulations recently issued by Gen. Miles: Military engineering, civil engineering, electrics, ordnance and armor. The term of instruction for engineer officers will be two years, for other officers 10 months; the course of instructions for enlisted men is that prescribed by the Chief of Engineers. The purpose of the school is to impart instructions to such officers as may be detailed for this purpose; to prepare junior officers of the Corps of Engineers for the active duties of their profession, and to provide for the thorough theoretical and practical instruction of engineer troops. It is also the purpose of the school to make experimental research in all relating to the duties of the engineer corps and to disseminate the information so obtained. The school will be governed by the rules of discipline provided for military posts as well as by special regulations; and the course of instruction will be immediately under the control of the Chief of Engineers.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

The ordnance experts of the army condemned the Gathmann gun when it was submitted to them, but its promoters carried their scheme to Congress and succeeded in obtaining a government appropriation to construct and test their invention. The test has just been completed at Sandy Hook, and has resulted quite as the experts predicted. The gun fired its projectile against the armor-plate, and the high explosive with which it was charged was properly fired; but the only result was a dent in the plate.

Mr. Gathmann is only one of many inventors who have conceived the idea that if by some means a projectile charged with high explosive could be thrown at an enemy and fired in his vicinity, a great advance would have been made in the art of war. So the last ten years have seen a multitude of special guns, special projectiles, special shells and what-not, all calculated to attain this end. But the whole list of pneumatic guns, cushioned shells and other devices looking to a similar end have been made obsolete and useless by the successful production of high explosives which can be fired from an ordinary gun with ordinary powder charges. In a paper elsewhere in this issue, Capt. Babbitt, the officer in charge of the Sandy Hook proving grounds, records the marvelous results which have been attained in this direction. That a high explosive can be made to withstand not only the shock of firing from a gun, but the shock due to striking and penetrating a 12-in. armor-plate, and then be exploded by a fuse after passing through the plate and backing is a remarkable illustration of the success which has been attained in the preparation of high explosives for ordnance use.

The effect of this new advance upon the long struggle between guns and armor is worth notice. It is well known, of course, that the gun has outstripped the armor in recent years. That is to say, it is no longer possible to make a ship invulnerable to the guns of her adversaries. On the other hand, armor-plating has hitherto caused shells fired against it to explode on impact, and such explosion, on the outside of armor-plate, can do little or no damage. If armor-piercing shot were used, it has not hitherto been possible to charge it with explosive, and a vessel might have her sides penetrated by quite a number of such shots and yet not experience any serious injury. The new advance above noted, however, changes the situation entirely. When a projectile can pass through a foot of solid face-hardened armor and explode inside a vessel, its fragments being propelled by fifty pounds or more of high explosive, it is evidently within the possibilities that a single effective shot may entirely disable a full-armored battleship.

Some of the disadvantages under which most municipalities needlessly allow themselves to labor when dealing with franchise corporations are intelligently discussed in a recent editorial in the Chicago "Tribune." The particular points which that journal wished to make were that the local transportation committee of the city council, in negotiating with the street railway companies for the renewal of their franchises, is quite helpless, at many points, because of the utter lack of engineering knowledge on the part of the members of the committee. The interests of the street railway companies, on the other hand, are ably protected by the best engineering, as well as legal, talent. In the course of its editorial the "Tribune" says:

> It is time that the tranportation committee realize (1) that the traction question is primarily an engineering one, (2) that the members of this committee are not capable, unaided, of "settling" the basic engineering features of that question, (3) that the city ought not to be placed at the mercy of traction engineers in respect to those features, and (4) that the best engineers obtainable should accordingly be secured to study and report upon this question in behalf of the city.

This is sound doctrine, and is applicable to other classes of franchises, and to other cities than Chicago. The Chicago transportation committee has shown by its recent report (see editorial note in our issue of Nov. 7) that it has very good ideas on many phases of the important franchise questions with which it is confronted. If the people and press of Chicago stand ready to support it, it is fair to assume that it will gladly secure the engineering advice of which the city just now stands in need.

NCREASING THE DUES IN THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The proposed increase in annual dues in the American Society of Mechanical Engineers was discussed in an editorial in our issue of Oct. 3, and has been the subject of several communications since published in our department of "Letters to the Editor." For the most part, however, this discussion has proceeded on the basis that the increase in dues was to be made for the purpose of building a new and larger house for the society in New York city. But by an official circular issued to the members just after the appearance of our editorial it appears that this is not the case at all. Instead, to quote from the circular:

> Either the expenditure of the society must be curtailed in directions which would be followed by a corresponding loss of efficiency and of the return to each member, or the dues paid by each member must be raised, to provide a fund from which present indebtedness may be paid, any unusual demand may be met, or any unusual opportunity be availed of.

To learn that an increase of dues was deemed necessary to meet the ordinary running expenses of the society has been a surprise, we are sure, to practically the entire membership. It was known in a general way that the growth of the society had been a steady and gratifying one, the number of members having practically doubled during the past ten years. During this period, also, the society has paid $32,000 of the debt on the society house, or, in other words, it has had an average surplus of income over expenditures of over $3,000 per annum. With this record of past experience, and remembering that the total income of the society, by the last annual report of the council, is in the neighborhood of $42,500 per annum, the members had every reason to suppose the society to be in a highly prosperous financial condition, and more likely to announce a reduction in the annual tax assessed upon the members than an increase.

What is the reason why the society which got along comfortably ten years ago on an income of $18,000 now confesses itself financially cramped with an income of over $42,000? That is the question which the average member asks, and he finds no satisfactory answer to it in the circular issued by the secretary, referred to above. Some figures concerning expenses which are given in that circular, however, are worth analyzing a little.

It appears that the entire cost to the society of publishing its "Transactions," including printing, engraving, binding, pamphlet copies of the papers and all other direct expenditure on the publication, amounted last year to $6.18 per volume. In the same year the actual total expenses of the society amounted to $20.81 per member. In other words, for every dollar spent by the society on its publication, 2⅓ dollars were spent in maintaining its headquarters, in salaries and in other expenses in connection with the conduct of the organization.

If, then, it is decided that expenditures must somewhere be curtailed, it is self-evident that much the larger opportunity exists in the indirect expenses of the society. In view of its successful conduct on a much smaller income in the past, it ought to be quite possible to reduce these "indirect expenses" without sacrificing in any way the quality and value of the "Transactions."

Searching still further for a reason for the alleged financial straits of the society, we find a comparison between the average total expenses of the society per member and the average income from dues. It is said:

> It appears that for the last three years the society has not been able to meet its total expenditure from dues only. It has only kept its head above water by other sources of income, such as sale of its publications to outsiders and by applying a portion of its initiation fees each year to current expenses. It is regarded as an unsound financial policy to spend the initiation fees in this way.

Again, in a later circular, to which we shall refer further on, we are told that "the present returns to the members, in the form of publications and otherwise, cost a sum per annum greater than the aggregate sum received from the members in dues."

Well, suppose it does, is there anything wrong or out of the way in that? What is the money received from initiation fees and from sales of publications to be used for if not for the running expenses of the society? Is there any warrant for treating this part of the society's income as a separate fund? Is not all the money received by the society, from whatever source, to be used alike for the society's benefit? So long as the total income shows a fair sized surplus over the total expenses, why should the members be told that "to maintain the present return at the present rate of dues is to run the society in debt?" A year ago the council's annual financial report showed a surplus income over expenses of about $1,850. The large influx of members during the past twelve months ought to fully offset any reasonable increase that may have been made in the expenses of the society during that time.

Another matter which deserves mention here is the statement which is made in the official circular that the foreign engineering societies have dues larger than those of the American Society of Mechanical Engineers. It is fair to say that that circular was prepared (though not issued) before the publication of Engineering News of Oct. 3, in which the dues of a large number of engineering societies, American and foreign, were stated. The actual fact is, as we then showed, that the dues in the American Society are now, and have been for ten years, higher on the whole than those of any other professional engineering society in the world, except the Institution of Civil Engineers of Great Britain and the American Society of Civil Engineers.

Referring again to the official circular, we find the following:

> The dues of the Institution of Civil Engineers of Great Britain, whose position in that country is the closest parallel to that occupied by the American Society of Mechanical Engineers in America, are four guineas a year

The council has felt that it is decidedly a better policy to raise the dues to such a point as seemed to be indicated by the experience and wisdom of the English society rather than adopt a policy of "tinkering" with the constitution and rate of dues at frequent intervals. It seems better to raise the dues to the point at which they will be likely to remain.

If this really is what the council felt, one is puzzled to know why they did not propose an increase of the dues to $20 instead of $25, for four guineas amounts in United States money to only $20.50. But the above is a misleading statement of the rate of dues in the English Institution. Here is a direct comparison of the present rates of dues of the two societies, reduced to United States money in both cases.

	Institution of Civil Engineers.	Additional, if resident in London.	Am. Society of Mech. Engineers.
Members	$15.38	$5.12	$15.00
Associate Mem. or Associate	12.80	2.56	15.00
"Student" or "Junior"	7.68	2.56	10.00

The extra tax on resident members is fully justified in the Institution by the fact that weekly meetings are held at the London headquarters of the Institution for the reading and discussion of professional papers. The American Society, however, holds only one meeting a year in New York; and so far as use of the society house in this city is concerned, we believe, except for a very few local members, the house is more used and more frequented by out of town members, who make it a headquarters while temporarily in the city, than by members residing in New York.

Notwithstanding this, the tax on resident members in the Institution is offset in the American Society by the subscription which resident members are annually called on to make toward expenses in connection with the annual meeting. In proof of this statement, we may quote from the call just issued with reference to the coming meeting:

The experience of late years would indicate that an average of $10 from the contributing members in New York city and surrounding localities would cover the expenses to be incurred.

It will be evident from the above comparison that the dues of the American Society are already quite as heavy as those of the English Institution, and that if the "experience and wisdom" of the Institution are taken as a guide, the dues had better remain at their present figure. There is still one other point in the comparison, however, which deserves notice. In the American Society all grades of membership, except the junior, pay the full rate of dues. In the English Institution full membership is bestowed only on engineers who have "acquired a considerable degree of eminence." Thus the associate members outnumber the members by more than two to one. In fact, of the total membership in the English Institution only two out of seven are full members. In view of this fact and of the comparison in the table above, it must be clear that the expenses attending membership in the American Society actually exceed the expenses of those connected with the English Institution.

Turning now to the membership list, we find that the proposed increase in dues, supposing that the membership does not fall off, would give the society an increased annual income of about $20,000. It is beyond question that the society is in no financial straits which place it in need of any such large increase in its revenues. Neither has the attempt to justify the increase by a comparison with other societies been successful. The question which the average member is certain to ask (and ask, we fear, in rather strong language) is what is it proposed to do with all this money?

On this important point the members were left pretty much in the dark in the secretary's circular dated Sept. 21. It was merely suggested that if the council were in a position to expend larger sums each year the way would be open to "conduct investigations along professional lines by committees of experts." It was also suggested that the society might engage in the preparation and distribution of index material, that more money might be spent on the library, and, finally, that "some provision for more satisfactory housing of the society and its library would have to be considered before long."

It appears from latest developments that it is the "research" idea that really lies at the bottom of this whole scheme of increasing the society's dues. Under date of Nov. 6, a second circular was issued to the membership, signed by a considerable proportion of the council of the society, in which this is stated in fairly plain terms. We quote as follows:

The council believes the profession of mechanical engineering and the society's own interest and those of its members would be best served by putting the society in such position that it would have money in its treasury for the conduct of research and investigation under committees of competent members, who should furnish the brains and direction for such researches, while paid assistants and the necessary apparatus could be provided from the society's income. The reports of such researches in the Transactions would enhance their value, and the society would take its position as the leading exponent of the highest grade of professional achievement. Will the membership sanction this policy by raising the dues for this object? Does the membership at large agree with the council that this broader policy is the wise and permanent one? The vote is really on this question.

In a further paragraph the council explicitly deny that the increase of dues is proposed with reference to changing the society's headquarters or the accommodation of its library. So then we at last have the issue plainly and squarely presented: Will the members of the society vote to raise the dues in order that funds may be provided for the conduct of "research and investigation?"

Now, we have no quarrel at all with the work of "research and investigation." A vast deal of it, good, bad and indifferent—mostly the latter—is being carried on all the time. Agencies and means for its conduct have been supplied with such astonishing liberality during the past two-score years that it is not at all infrequently a question of how they may be usefully employed. Stop and think for a moment of the amount of research that is being carried on. There are in the United States alone some fifty to a hundred experimental laboratories in connection with engineering schools. In Europe there are probably as many more. There are besides these the bureaus of investigation in connection with a hundred government departments, as many railway companies, many times this number of manufacturing establishments. Think also of the work done in developing and testing new inventions and new enterprises.

Is it not plain enough that the proper function of a great engineering society is not to engage in researches on its own account; but to put on record and make accessible for the general benefit of the profession the important results of researches carried on by the thousand and one different agencies already established?

Of course, there are certain classes of research which fall particularly within the province of an engineering society. The formulation and adoption of standards is one of these. The American Society of Mechanical Engineers has done excellent work in this field in the past, and it can do it in the future, we are fain to believe, without imposing additional burdens upon its membership. The fact is that tests or experiments desired in any work of this sort can almost invariably be secured at some engineering school or manufacturers' laboratory with little or no expense to the society.

It is true, as was stated in the Secretary's circular, that some foreign engineering societies have engaged in research work. In England, the most notable example of this sort is the work done by the Institution of Mechanical Engineers. That society has conducted through committees several elaborate investigations, some of which are still in progress. There came to our desk the other day the results of one of them, in the shape of a bulky pamphlet of 50 pages or more. It was entitled "Second Report to the Gas Engine Research Committee." That looked interesting, and we set to work to find out what practical results had been reached that would be of actual value to a gas engine designer or user. We cannot swear that there was absolutely nothing of value hidden in the mass of mathematics and tables and diagrams, and what-not that the pamphlet contained, but long and careful search made it evident that if it was there it was hidden, like Gratiano's "two grains of wheat in two bushels of chaff," so thoroughly that a new research committee was needed to discover it.

We do not believe the working engineers wants to use or pay for "research" of this brand. The fact is that research carried on for the sake of research is extremely apt to lead nowhere and leave off just where it started. The really valuable researches of the world are not made in such a way. Maunsel White and Fred. W. Taylor set to work to find a special tool steel which would stand a higher speed-cut than any steel on the market, and succeeded so well as to start a revolution in machine shop practice. A society might have appointed a dozen committees to make researches on tool steel, but there is little chance that any of them would have achieved any such practical result.

Finally, even if it be thought that the research business is a good one for the society to engage in, there comes the question, ought the society to place further burdens on its membership? This feature is lightly dismissed in the official circular as follows: "It is felt that to practicing engineers of the type represented in the society's membership, this increase is practically nothing so far as its restricting or prohibitory effect is concerned."

But we hear reports on every hand that it does not strike the members at all that way. There are, of course, among the members of the society very many men possessing wealth or in receipt of large incomes. The dues ought not to be gaged by the ability of these men, but by the purses of the working engineers, whose salaries are fixed, it must be remembered, not by the value of their services to humanity at large, but by the inexorable law of supply and demand.

From a pretty intimate acquaintance with engineers of all classes, extending over many years, we can bear testimony to the fact that high professional standing and a large income are by no means always associated. It is suggested in the official circular that the increase of dues might perhaps cause the withdrawal of "those less vitally interested in engineering." The actual fact is that such withdrawals would tend to lower the standard of the society rather than raise it. Engineering is at once a profession and a business. A raise in the dues will make little difference to many engineers engaged in profitable business, while it may make a very important difference to the professional engineer.

A word should be said also as to the increase in the dues of Junior Members. This is a particularly unfortunate feature of the proposed change, for the Juniors have no vote or voice in the society. They have joined the society on the supposition that they would have to pay only $10 per year, and if they are now forced to pay $15, many of them will have to resign and lose what they have paid in initiation fees.

In the official circular, there is an attempt made to show that the Juniors cost the society more than it receives from them in the way of dues; but the figures given prove nothing. The fact is that all the added expense to the society for an additional Junior or an additional member for that matter, is only the cost of the paper, press-work and binding on his copy of the "Transactions" and other society publications, plus a trifle for express and postage and another trifle for clerical labor in connection with his name. All this will fall very far short of $10 per annum. It is not true, therefore, as stated in the circular, that an increase in the proportionate number of Junior Members can cause the society expenses to exceed its income.

The above presents, it seems to us, fairly, and without prejudice, the main arguments against the proposed increase of dues, and it only remains to state how the question is to be decided. When the notice of the proposed increase was given at Milwaukee, and when the Secretary's circular was prepared in September, the idea was that the members present at the December meeting would alone have power to vote on the question. The great bulk of the membership living at a distance from New York were practically disfranchised, for there is no provision for voting by letter ballot on amendments to the "Rules" of this society.

Our contemporary, the "American Machinist," however, which has been fighting the increase of dues tooth and nail, discovered that under the New York corporation laws, members who could not be present at the meeting could give a proxy to some member who could be present and so record a vote for or against the amendment. That put a very different face on the matter. The

council of the society held a meeting and decided to send out proxy blanks to the entire voting membership instead of allowing the matter to be settled by vote of the members present only, as originally planned. At the same time a number of New York members who oppose the increase of dues, also arranged to send out requests for proxies to the membership, not knowing that action to this end had already been taken by the council. Thus, every member of the society has now ample opportunity to register his vote, in approval or disapproval, and the result of the ballot, which is to be taken on Wednesday, Dec. 4, will be awaited with interest.

LETTERS TO THE EDITOR.

Criticism of the New York Road Specifications.

Sir: In your issue of Nov. 7, the State Engineer of New York replies in part to my criticisms of present state road specifications, and in replying says that the criticisms would be "more valuable if they were based upon specifications that could in any sense be called 'present.'" Perhaps I do not comprehend the meaning of the term "present," but it seems to me that specifications under which road work was let this summer and is at this moment in progress, might well be called "present specifications."

The Fairport road in this county is in process of construction, and there are others to which every criticism that I have made applies.

Last year I published in local papers the criticisms which a few months ago I submitted to Engineering News, and which have just been published. Since the publication of those criticisms, and since the writing of the manuscript just referred to, I find that the State Engineer has changed some of the most recent specifications so as to permit the use of the full output of the crusher. The change was a wise one though it came none too soon. But there yet remain six more changes which would effect a far greater saving than this one, and I regret that the State Engineer has seen fit to ignore them in his reply. I refer to (1) the reduction of the standard thickness of macadam to 4 ins., not counting stone driven into subgrade as lost; (2) the regular, instead of semi-occasional use of gravel for foundation purposes; (3) the adoption of a standard width equal to half their present width; (4) the abolition of canal-like ditches; (5) the omission of a valueless "wearing coat" of screenings, and (6) the permission of such vegetable matter as grass roots in embankments.

Nor would a reply to these points of criticism be time wasted in view of the fact that local papers in this county have declared that they will oppose further state appropriations for road work until roads are designed so as to cost less than the $10,000 a mile which is being expended on state roads now building in this county.

Yours truly, Halbert Powers Gillette.

791 Powers Block, Rochester, N. Y., Nov. 9, 1901.

Irrigation in Eastern Oregon.

Sir: Most people in the "East" look upon Oregon as a decidedly rainy region, whereas this is true only of that portion west of the Cascade Mountain range, comprising about one-third of the area of the state.

In eastern Oregon there are fully 1,000,000 acres of arid land—a desert waste waiting for irrigation. Along the Deschutes River there are probably 500,000 acres of desert land, and already four or five irrigation companies are planning to divert water from this stream. The problem of diversion is a difficult one, on account of the immense lava flow which once took place in this region, filling up the valleys and changing the water courses. The flow is probably not less than 2,000 ft. deep in places, and is capped with a soil of varying depth and extent, as in any lava country.

Ditching in certain parts of the desert has been somewhat problematical, as the lava lies close to the surface and there are innumerable caves of greater or less extent. One ditch has been constructed about five miles in length, water being turned in at the head and allowed to flow to the front, forming lakes and ponds on the desert. Recently the water in one basin of about an acre in extent began to sink rapidly into the ground, entirely disappearing in about ten minutes. Some of the workmen were grouped together watching the subsidence of the water when suddenly there was a loud explosion almost at their feet and a large mass of dirt and rocks weighing about six or eight tons was thrown up into the air fully 8 or 10 ft. high, disclosing an underground cave. The cause of the explosion, of course, was compressed air in the cave, resulting from the pressure of the water. The men are now wondering what will happen next.

In three places on the desert, five miles apart, water can be heard rumbling beneath the surface, and it is supposed there is an underground river. Twenty-five miles northward a large body of water gushes out from the lava at Crooked River, probably with a volume of about 1,500 cu. ft. per sec.

About 15 miles from the river are caves known as the Ice Caves. Last July the writer made a reconnaissance on the desert, taking along two barrels of water. The water getting low he replenished his barrels at the Ice Caves and reappeared at camp with a barrel of ice which was heartily welcomed, the thermometer being 109° F. in the shade. About the same time, that is during midsummer, ice was found in one of the main canals 7 ft. below the surface of the lava.

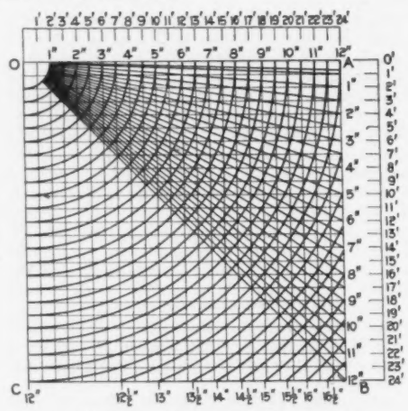
Altogether there are about 200,000 acres of land which can be irrigated, one-fourth of which is of excellent quality, almost free from lava. With the rapidly diminishing public lands, and the rapid increase of population, it is estimated that most of this land will be under cultivation within the next 10 or 15 years. Very truly yours,

Albert I. Frye, M. Am. Soc. C. E.

Bend Crook Co., Ore., Nov. 6, 1901.

Diagram for Determining Bevels.

Sir: I enclose a diagram drawn to half scale for solving any right triangle of which the legs do not exceed 12 ins. in length, also for determining the bevel expressed in feet under 24. The diagram is self-explanatory. I made a diagram similar to this about six months ago and have found it very convenient.



A Diagram for Determining Bevels.

With the exception of a diagram described in your issue of Oct. 31, involving some of the same principles, this diagram is original with me as far as I know. Hoping that this may prove of use and interest to some of your readers, I am, yours truly,

J. L. Tatlock, C. E., with Phoenix Bridge Co.

Phoenixville, Pa., Nov. 10, 1901.

(We have at different times received diagrams similar to the above from engineers and draftsman. The idea embodied has been in use a long time, and seems to be one that very many draftsmen run across independently. We have, therefore, never published such diagrams hitherto, and we presume that many will recognize what they have considered their own property in the one we reproduce herewith. The diagonal lines are often drawn to read degrees directly, so that most trigonometrical operations on right triangles may be performed graphically. Within its limits of accuracy, a diagram of this kind may in many cases prove convenient.—Ed.)

Street Railway Bonds and Electrolysis in Seattle.

Sir: My first intimation that the electric currents of the street railways in Seattle were not being properly returned to the power house was several months ago, when a horse, which had stepped on the rails of the tracks near Madison St. and Western Ave., was knocked down.

The tracks and planked roadway for several blocks in this vicinity were elevated on piles over salt water and the tracks ended in a pile of old scrap iron about 100 ft. from where this accident happened. Sparks could be seen in this scrap iron whenever a car was being operated over the last mile of these double tracks.

As a temporary remedy the street car company bonded the four rails together with trolley wire and also ran a wire with a piece of rail soldered to the end of it from the tracks into the salt water. Afterwards the electric railway tracks were bonded to the cable road on Madison St. Sparks were not seen in the scrap-iron pile after that, neither were there any more accidents from stray electric currents in this vicinity. Evidently some of the current was conducted by these wires to the salt water and some to the cable tracks where it was again conveyed through the moist earth to the underground metal structures, such as water mains, gas mains and telephone conduits, and wherever it left these structures they were damaged by electrolysis.

Several weeks later I tried a little experiment about two miles from the power house. I filed the rust from the edge of a street railway track, and also from a small water pipe near by. I then fastened a piece of No. 6 B. & S. gage copper wire to one end of a piece of No. 12 steel telephone wire. The other end of the steel wire was wound snugly around the water pipe. Holding the wires between two sticks I touched the free end of the copper wire to the bright spot on the rail and obtained a spark. A car was approaching several blocks away and I held the copper wire against the rail for a few seconds and found when I went to pull it away that it was welded tight to the rail. In a few seconds more the steel wire blazed up like an arc light and burnt off.

This proved that the tracks were very poorly bonded or that there was good electrical connection between the water pipes and the bus bars of the electric generators in the power house. I found afterwards that the Clark bonds were used to a certain extent on these tracks, but most of the bonding was done with copper wire soldered to the ends of the rails. These copper-wire bonds not being large enough to carry the current were giving much trouble, as they would come loose two or three weeks after they were soldered on. I was also informed that the company was making connections at the power house between the water pipes and the bus bars of the dynamos.

Several weeks ago a piece of wrought-iron gas pipe was removed from the earth near the power house that was literally honeycombed with holes that were burned in by the electric current. A few blocks from this place the planking of a bridge was set on fire at the junction of two hot rails and a pipeman in the water department was badly burned and the threads of the pipe were burned out while he was trying to make a connection between two water pipes adjoining the power house. Voltmeters have been obtained and the city is making some experiments. Meanwhile the water pipes have been connected to the dynamos with copper wire by permission of the superintendent, which I am afraid is very poor policy.

In my position as city inspector, I have had occasion to examine many different kinds of electric railway bonds and was surprised at the number which came loose at some of the joints in from two weeks to a year after the bonding was done. Most of the bonds that I examined were of copper, soldered to the rail, and as this kind seemed to loosen very rapidly I soon formed the opinion that the solder was the weak part of the bond. In reality the joints of electric street railway tracks should not be of higher resistance than an equal rail length, but I am sorry to say this is seldom if ever carried out in actual practice, and a joint that has an electrical resistance of 25 microhms is supposed to be well bonded.

Walter Scott Wheeler,
City Inspector of Franchises.

City Engineer's Dept., Seattle, Wash., Nov. 5, 1901.

(After all that has been printed on the subject of electrolysis by stray return currents from electric street railways, it seems well-nigh incomprehensible that either a street railway company or a city can allow such a condition of affairs to exist as the above letter reveals. The railway company is wasting and worse than wasting a good share of the current generated at its power house; and the underground mains in the city streets are being destroyed at a rate which would not be tolerated for an instant if the mischief were not hidden from sight.

The legal question whether a street railway company is responsible for damage done by its ground return currents, after it has done all that the present state of the art permits to keep these currents off the underground piping, has not yet been settled by the courts; but there can hardly be a doubt where such gross negligence is shown by a street railway company as is evident in the above case that it can be made to pay for every dollar of damage done to any and every pipe and conduit in the city streets.—Ed.)

COMPETITIVE TESTS OF STEAM PIPE COVERINGS.

Tests of steam pipe coverings have been carried on for the last six weeks at the new power house of the Manhattan Elevated Ry., at 75th St. and East River, by Mr. Geo. H. Barrus, M. Am. Soc. M. E., of Boston. The tests are arranged on a large scale, and extend over periods varying from one week to six weeks, so that the results may be taken to be quite reliable. The full series of tests is not yet completed. On Tuesday, Oct. 12, a number of prominent engineers inspected the test apparatus on the invitation of Mr. Barrus, who read a few explanatory remarks on the method of conducting the test.

Steam pipe coverings in this test are arranged in three different classes: (1) 2-in. coverings (for

2-in. standard pipe) for low pressure steam, (2) 2-in. coverings for high pressure steam, (3) 10-in. coverings for high pressure steam. Each style of covering tested is applied in a thorough manner to a certain length of pipe, and a certain pressure of carefully dried steam is maintained in the pipe by supply from a header at one end; the other end is fitted with a small steam cock, in the pipe itself, and a water-leg below fitted with gage glass and water cocks. A slight outflow of steam through the pet cock, amounting to about ½ HP. for each length of pipe in the test, ensures a practically uniform temperature within the pipe. The water condensed in the pipe drains to the water-leg, whence it is discharged at intervals into a weighing cask below. The amount condensed during a measured time-interval, as nearly as may be eight hours per day, is weighed in this manner, and the hour average of many days' test taken as an index of the rate of loss of heat from the covering.

Coverings of class 1 mentioned above are tested each on 100 ft. in length of 2-in. pipe, the constant steam pressure being 80 lbs. Five such lengths of pipe permit of simultaneous test of five coverings.

Class 2 is similarly tested on 100 ft. of 2-in. pipe with a steam pressure of 150 lbs.; five pipes are tested at once. Class 3 is tested on 50 ft. of 10-in. pipe, only two such pipes being set up for test. In class 1 four pipes are used for continuous long-time test; on the fifth pipe all the coverings are tested successively for shorter periods of time, so as to determine whether differences in pipes themselves and in application of coverings cause any errors to creep in.

The coverings were bought in the open market. After each covering was applied, the makers were asked to examine it and remedy any errors or deficiencies in its application. Temperatures of steam, air and water, pressure of steam, moisture in atmosphere, etc., are carefully measured, and the existence of air currents is frequently tested for in order to avoid any chance vitiation of results.

The series of tests is not yet completed, as stated above, and the results that have been obtained to date have not yet been reduced to final form. The amount of water condensed in each length of pipe per hour (with an air temperature of 55° to 60° F.) has been, however, approximately determined. The figures obtained show that the different coverings vary but slightly in efficiency. In class 1 the condensation is 13.5 to 15.1 lbs. per hr.; in class 2, 10.5 to 13.8; in class 3, 10.7 to 13.9; the figures given are the extremes of condensation in each class. The differences between different coverings are, however, fairly regular, and have been determined with little probable error. Roughly, the order of efficiency is as given in the following table, which Mr. Barrus gave out on the occasion referred to:

Class 1.	Class 2.	Class 3.
(1) John's Asbestocel.	(1) John's asbesto-sponge hair felt, 3-ply.	(1) John's asbesto-sponge felted.
(2) N. Y. air cell.	(2) John's asbesto-sponge hair felt, 2-ply.	(2) K. & M. magnesia (85% magnesium carbonate).
(3) Carey's molded.	(3) John's asbesto-sponge felted (sectional).	(3) Asbestos fire felt, Navy brand.
(4) John's molded.	(4) K. & M. magnesia (85% magnesium carbonate).	(4) Watson's Imperial.
(5) Gast's Ambler air cell.	(5) Asbestos fire felt, Navy brand.	

In arranging the coverings in the above order, efficiencies only were taken into account. No differences in thickness of covering, cost, durability, etc., were considered.

MASSACHUSETTS STUDIES IN THE PURIFICATION OF MANUFACTURING WASTES.

At the monthly meeting of the New England Water-Works Association, on Nov. 13, Mr. H. W. Clark, Chemist of the Massachusetts State Board of Health, read a paper in which he reviewed the recent work of the board in the study of the disposal of manufacturing wastes. The full paper will appear in an early issue of the journal of the association. Some of the most interesting points may be noted as follows:

A number of streams in Massachusetts are receiving large volumes of manufacturing wastes. Some are badly polluted already, and sooner or later there will be a general demand for a cessation of this growing evil. The principal sources of pollution are woolen mills, paper mills and tanneries.

Woolen mills send into streams large amounts of organic matter, washed from the wool in its cleansing, and lesser amounts from washing cloth. Domestic sewage ordinarily contains 50 to 200 parts of solid matter per 100,000, but wool liquors have been found to average about 2,500 parts per 100,000. The studies made by the board indicate that chemical treatment of wool wastes is not satisfactory, but that when diluted by domestic sewage (11 to 1, in the case of wastes from Clinton, Mass.), the sewage could be readily purified by intermittent filtration. The wool wastes applied to one of the experimental filters were first passed through a septic tank. The final effluent was better than in the case of the bed receiving crude sewage, and the filter was not so badly clogged at the end of the experiment. Wastes from washing wool are liable to contain sand and grit, some of which may be profitably removed, prior to filtration, by sedimentation.

In England, the author understands, municipal authorities are insisting that wool-scouring wastes must not be discharged into sewers without previous treatment.

Tannery wastes are easily purified by intermittent filtration. Wastes from a sheepskin tannery gave no difficulty. Those from a calfskin tannery, where the skins had been treated with arsenic, would not nitrify when applied directly to the filter beds, but when first passed through a coke breeze strainer or over iron filings there was no difficulty. In the latter case the arsenic united with the iron of the filings, thus removing the germicide from the sewage.

Paper mill wastes present little difficulty, except on account of their volume. If diluted with domestic sewage they may be filtered through sand, or rapid filtration through coke or cinders, even at the rate of 1,000,000 gallons an acre a day, will remove most of the polluting matter. This is due to the fact that the bulk of the pollution is suspended matter, principally cellulose. This forms in a felt-like mat on the filter, and may be removed and burned.

During the present year the board has made studies of silk mill wastes. At least 50 different chemicals are used at the mill in question. It was found that for preliminary treatment coke strainers were more effective than a contact bed or a septic tank.

Thus far "the board has no power to require purification of manufactural wastes, and communities are slow to demand such purification."

Prof. Leonard Kinnicutt, of Worcester, told what he had recently seen in the way of the treatment of manufacturing wastes in England. Septic tanks do not give the best of results with acid sewage. The woolen manufacturers near Manchester generally treat their wastes chemically, and recover grease and indigo. The sewage of Bradford, England, which is heavy with wool wastes, is probably the worst in England. Chemical treatment proved a failure. Experiments made by the city with the septic tanks and contact filter beds were also a failure. Some of the manufacturers treat their own wastes, and, it is said, make money in doing so. In general, those English manufacturers who treat wool waste use chemicals first, then filter the effluent. The action of septic tanks on wool wastes appears to be very small.

NOTES FROM THE ENGINEERING SCHOOLS.

CORNELL UNIVERSITY.—President Schurman, in his late report, notes that the largest class of civil engineers graduated in June that has ever gone out from the university. Prof. Fuertes, Dean of the College of Civil Engineering, says that the 42 rooms now occupied by engineering students are entirely inadequate for the purposes of the college, and laboratories, drafting and lecture rooms are so crowded as to hinder the efficiency and growth of this branch of the university. He urges that steps be taken at once to add to the present space available and also to the teaching staff. Prof. Robert H. Thurston, Director of the Sibley College of Mechanical Engineering and Mechanic Arts, reports for 1900-1901 a total of 670 students and 36 instructors of all grades; and he, too, calls for more room and a larger staff of teachers, in addition to the improvements—costing $80,000—now being made by Mr. Hiram W. Sibley, the son of the founder of this college.

President Schurman notes that after personal investigation by a committee sent for this purpose the new University of Birmingham, England, has adopted the system of technical education which the committee found at Cornell. While the total property of the university now amounts to $10,870,209, including buildings and equipment, the average annual increase of 200 students calls for at least ten new buildings. Under date of May 27, 1901, Mr. John D. Rockefeller offers to give to Cornell University $250,000 for the erection and equipment of a building to be devoted to physics, or to the humanities. But he conditions this gift upon the raising of an equal sum from other sources, and President Schurman earnestly appeals to the friends of the university to assist in raising this additional sum before Commencement Day 1902, the time limit of Mr. Rockefeller's pledge.

LEHIGH UNIVERSITY.—This institution is erecting a stone laboratory, 90 × 43 ft., to be used in connection with steam engineering work in the mechanical engineering department. The university will add next fall a new and extended course in electro-metallurgy, the first of its kind to be established in this country.

PURDUE UNIVERSITY.—Through the courtesy of the engineering department of the New York Central & Hudson River Ry. Co. this institution has received an exhibit of primitive railway track, recently uncovered on the line of the old Mohawk & Hudson Ry. It includes stone blocks, stringers and rails. The university already has an exhibit of the so-called "bull-rail" track from the old Central Railway of Georgia, deposited by Mr. Theodore D. Kline, General Superintendent of that road.

UNIVERSITY OF CINCINNATI.—This university has added courses in mechanical and electrical engineering to its civil engineering department. And to this end a shop with 25,000 sq. ft. of floor space is being erected, to be equipped with a modern and complete outfit. Prof. C. W. Marx is at the head of the department of engineering and director of the Technical school.

THAYER SCHOOL OF CIVIL ENGINEERING.—The class of 1902 in this school, under the personal charge of the director, made a tour of inspection in October to Worcester, Boston and Lawrence. The class visited the sewage purification works near Worcester, the Wachusett reservoir and dam, the sewage plant in Clinton and the stone dam near there, the South Works of the American Steel & Wire Co., and in Boston the sewage disposal works, experiment station of the Board of Health, the Boston Bridge Works, the shops of C. L. Berger & Sons, the Boston elevated roads, the U. S. Navy Yard, etc. At Lawrence they visited the water filter and pumping plant. A trip to the copper mines and reduction works, at Copperfield, Vt., is contemplated.

UNIVERSITY OF VIRGINIA.—The "Alumni Bulletin" for October contains much of interest relating to this university. Among other things noted is a proposed memorial road, 2½ miles long, to connect the tomb of Jefferson, at Monticello, with Charlottesville, near the University of Virginia, which he founded. An appeal is made to the admirers of Jefferson, and to all lovers of good roads, to aid in the construction of this road under the supervision of the Road Inquiry Office of the Department of Agriculture. The estimated cost is $10,000. Col. Thomas H. Carter, Proctor of the University, sets forth the financial status and the educational advantages and facilities of the university.

THE FAILURE OF THE ELEVATED WATER TANK AT FAIRHAVEN, MASS.

The failure, on Nov. 9, of the elevated water tank at Fairhaven, Mass., is particularly notable because the tank was one of the first with a curved bottom ever erected, at least in this country, and one of the largest of the type built up to the present time. In addition, this is the only failure, so far as we remember, of a tank having a curved bottom.

A general view of the tank, drawn from a photograph taken just after its completion, in 1894,

Fig. 1. View of Water Tank at Fairhaven, Mass.

(Redrawn from a photograph taken just after the tank was completed. Practically the same view appeared in Engineering News for Sept. 5, 1895.)

is shown by Fig. 1. Figs. 2 to 5 are views of the wreck. Fig. 6 is a sketch of the junction between the sides and bottom of the tank, made from measurements taken at the wreck.

Before considering the failure, the main features of the tank and tower may be noted.* The tank proper was 35 ft. in diameter and 50 ft. high. The bottom was in the form of an inverted cone for two circumferential courses of plates, then changed to a spherical form, composed of a single plate. Through the center of this plate the supply pipe entered by means of a stuffing-box. The total depth of the bottom appears to have been about 12 ft. The tank was supported (Fig. 6) at its outer edge only, on a circular girder, 3 ft. deep, resting on twelve inclined posts. Each post rested on a large dressed capstone, and was secured to the stone and the rubble masonry foundation below by two anchor bolts. The bottom of the cylindrical portion of the tank was 100 ft. high, and the finial of the conical roof was at an elevation of 198½ ft. The roof was galvanized iron. Otherwise the whole structure was of steel. The original specifications called for steel for the columns, or posts, only. The original descriptions state that the plates composing the tank were ½-in. thick in the lower ring of the sides, and also in the top ring of the conical bottom, diminishing in thickness each way. Measurements on Nov. 14 showed that the first, or upper ring of the bottom was composed of ½-in. plates, as stated, and that the second ring was of ⅝-in. plates. The final, spherical-shaped plate was not measured, but the original descriptions would indicate that it was ¼-in. thick.

The tank failed at a few minutes past 4 p. m., Saturday, Nov. 9. From all accounts, there was no wind at the time. The temperature was probably near, though above rather than below, freezing. The tank at the time of failure, according to a statement by Mr. Nye, was filled within 9 ft. of the top, or contained 41 ft. of water. When the tank reached the ground its conical bottom appears to have been nearly, if not wholly, separated into three parts. One of these fell free from the sides onto the foundation, while the other two were swung around with the cylindrical part of the tank. It also appears that these two bottom sections were largely separated from the sides of the tank, but just how much cutting was done in clearing up the wreck cannot now be stated with certainty.

The cylindrical portion of the tank was intact around the whole lower ring, and showed no signs of failure anywhere, except for a few openings in some of the upper joints caused by the shock of falling.

There were several eyewitnesses of the accident, but as those whose accounts are reported were hurrying for their lives the information gleaned from them regarding the origin of the failure is of a vague character. All agree, however, in stating that there was a sudden burst of water from the tank, followed by an almost instant collapse. So speedy was the discharge of a large volume of water that two boys, passing at the time on a tandem bicycle, were swept along by the flood. One boy, on observing the break, jumped off the tandem to escape to the rear, while the other tried to push by, but neither one escaped without injury.

The sequence of events during the failure must be determined, if at all, from the vague statements just mentioned, from the position of the various parts of the wreck, and the character of the tears and deformations in the tank bottom and in the tower.

The four views give a fair idea of how the structure looked after it fell, except that none of them clearly show the position of that part of the bottom that was completely detached from the sides of the tank. It will be noted, however, that the roof, the tank proper, and a large part of the bottom, lie across or beyond the western half of the foundation lines; also that the tank, except the portion which fell onto the foundation, was carried way to the front, so the lower end of the bottom rested in the road. The bottom portions of six or seven of the supporting posts fell upon the top of the tank, as did also the two lower lengths, or 40 ft. in all, of the central feed and supply pipe.

A visit to the wreck by a member of the editorial staff of this journal, on Nov. 14, resulted in the following observations: A portion of the bottom of the tank struck the ground, or the concrete beneath the tank, in the southeast quarter of the foundation. This included 11 of the 28 plates composing the upper and six of the 14 plates composing the lower ring of the bottom plates, together with the whole of the single spherical-shaped plate which formed the lowest part of the bottom, and through which the central feed and supply pipe passed. Attached to the latter plate was the upper end, or flange, of the stuffing-box. The section of the bottom just described may be seen in part, beyond and to the left of the foot of the supply pipe, Fig. 4, and beneath, behind and to the right of the group of men in the left of the view, Fig. 2. The spherical-shaped bottom plate of this section rests on the concrete, while the radial plates are bent over, down, and around, so only a small portion of their area appears in the views. The location and shape of this section is given in more detail below.

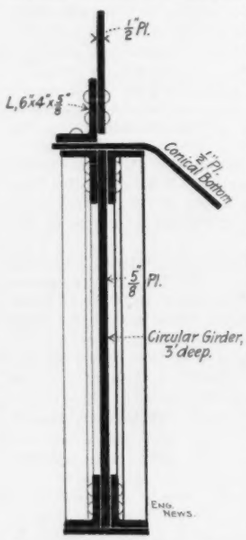


Fig. 6. Sketch of Junction of Cylindrical and Bottom Portions of Tank, and Supporting Girder.

The girder and posts which supported the tank, except as already mentioned, were so thrown about, twisted, bent, and buried beneath the tank as to make it difficult to describe their location. One or more segments of the girder appear to have been torn completely free from all its connections. The foundations of the twelve supporting posts are uninjured, but two capstones were hurled to some distance from their beds, and a third was twisted about so it rested diagonally across its bed, as may be seen in Fig. 4.

The concrete pavement over the area included within the foundation line was damaged at several points, but nowhere so as to affect in any way the stability of the posts. Fig. 4 shows an elliptical-shaped hole, washed clear through the pavement, between the center and the north side. This hole must have been gouged out by a jet of water from a break in the bottom. The hole is about 8 x 12 ft. in plan, with its northerly end about 2 ft. from the corner of one of the capstones. There were a number of other breaks in that part of the concrete pavement which was not hidden by the wreck, but all these were at the edges.

FIG. 2. GENERAL VIEW OF WRECKED WATER TANK AT FAIRHAVEN, MASS., LOOKING S. W.

Fig. 6 shows how the bottom of the tank was attached to the sides, and also how the weight of the whole tank and its contents was supported. The upper side of the bottom ring, it will be noticed (also see Fig. 2), was flanged, then riveted to the angle iron attached to the side of the tank. The rivets in this single row, from measurements on the spot, were about ⅞-in. in diameter, 2¾ ins. c. to c., and countersunk into the under side of the

*An illustrated description of the structure was published in our issue of Sept. 5, 1895. Our description was based on drawings supplied to us by the designing engineers, and on a paper by Mr. Joseph K. Nye, Superintendent of the Fairhaven Water Co., published in the Journal of the New England Water-Works Association for June, 1894. The details of the actual tank differ in several important particulars, from both the original drawings and the illustrations accompanying Mr. Nye's paper. In other words, none of the descriptions published in 1894 and 1895 were accurate in detail; therefore they should be used with caution in trying to establish the cause of the failure.

flange, so the bottom of the flange would have a full bearing on the supporting girder.

Referring again to the view, Fig. 2, it will be seen that a part of this joint held, but just how much is uncertain. When the writer visited the ruins, the conical bottom had been entirely disconnected from the tank proper. It had also been cut into sections, some of which had been moved to clear the highway. One thing seemed certain: Wherever the bottom and sides parted in the wreck it was, with few exceptions, the rivets that failed. A careful examination of the whole circumference of the angle iron attached to the lower edge of the sides of the tank showed only three

FIG. 3. VIEW SHOWING PART OF CONICAL BOTTOM AND PART OF TANK PROPER, LOOKING N. E.

stretches of about 1½, 1½ and 8 ft., respectively, where the flange of the bottom plates had ruptured and was still attached to the angle which united the bottom and sides of the tank. These three stretches included 52 rivets that held. The conical bottom plates, at this junction, did not tear elsewhere. The portion of the bottom of the tank that fell within the foundation line, as has been stated, included 11 of the 28 plates composing the outer ring of the bottom. Even if the junction of the bottom and sides failed in these eleven plates, only, there would have been approximately three rivets that failed for every one that held; or three-fourths of the failure here would have been due to the riveting, and but one-fourth to rupture in the flanged part of the bottom plate.

This flange, it must be remembered, was weakened by the countersinking for the rivets, yet where the flanged plate tore the rupture was along the line of the rivet holes for only two stretches of six rivets each, this being in the 8-ft. rupture.

The rivets in question, so far as they remained in evidence on Nov. 14, failed in their lower, or countersunk, heads. Most of these heads pulled right through the bottom plate, the edges of the countersunk head pulling over the end. None could be found which had sheared off.

With one exception, all the radial ruptures in the bottom appear to have been in the butt straps, or cover plates, of the radial joints. This exception showed a tear in a plate composing the lower conical ring. The tear was along the outer line of double rivets. The narrow strip of plate thus left attached to the butt plate was included in the section of the bottom that fell on the foundation. Few if any of the radial rivets in the butt straps appeared to have failed, except where the lower ends of the butt straps overlapped and were riveted to the spherical bottom plate. Here there were three thicknesses of metal: The bottom plate was on the inside, then the radial plates, then, outside of all, the butt straps. The rivets passing through these three thicknesses of metal nearly all failed; or to be more accurate, they were not in place on Nov. 14. The butt straps were doube-riveted to each of the two plates whose junction they covered. On the lower conical ring they were ½-in., and on the upper ring, 5/8-in. thick. A number of butt straps were seen which showed transverse cracks for their whole width. These were where the section of the conical bottom now resting on the foundations had become bent in falling. The bends were moderate.

The spherical-shaped bottom plate, through the center of which the supply pipe entered the tank by means of a stuffing-box, was intact. Six plates of the inner course of the conical bottom were torn off from the central plate, the fracture following along the circumferential joint mostly, if not wholly, along the upper line of the double row of rivets. Where it crossed the cover plates the rivets pulled out. It may be mentioned here that the 6, out of 14, lower conical plates that remained attached to the spherical bottom plate were at the southwest side of that plate, as the latter rested on the foundation. The chord to the arc of these six plates was little short of the diameter of the lower edge of the ring which they formed, and lay northeast and southwest.

The flange of the cast-iron stuffing-box attached to the center of the spherical bottom plate was snapped off short. All the rivets held. The supply pipe was of wrought iron, 10 ins. in diameter. It was firmly supported at its base on a masonry foundation.

Nearly all the fractures in the metal, whether of tank or supporting tower, were sharp and clean, while some of those in the plates of the posts appeared almost as nearly at right angles to the length of the posts as if cut by ruler, and also quite smooth. Distinct laminations of plates were noticed at two points. Some of the tie rods showed a good fracture; others were snapped off very short.

Except at the junction of the bottom and sides of the tank, and where the radial butt straps overlapped the spherical central bottom plate, the rivets appear to have stood well. The countersunk rivets through the flanged bottom appeared to have been poorly headed in and did not fill the holes well.

The butt straps, although thicker than the bottom plates, seem to have ruptured more readily than the latter, and to have been of poorer metal than the plates whose joints they covered.

The inside of the tank showed signs of corrosion, scarcely any at the top, but more and more towards the bottom. The outside of the conical bottom had been painted quite recently. A double trolley track passed close by the tank, but we have not seen the electrolysis theory advanced by any one. Mr. Nye, the superintendent of the water-works, stated to the New Bedford press that he had never seen any signs of weakness; that he had inspected the tank every month or so since it was erected, and was all over it three or four days before the failure. On the other hand, Mr. A. S. Negus, pumping engineer of the New Bedford water-works, is quoted as saying that there were troublesome leaks in the bottom of the tank, and that some of the rivets may have been weakened thereby,

Our effort thus far has been to give as clear an account as possible of the actual conditions as observed after the wreck. To this account there must now be added, to enable the reader to form his own conclusions, some reference to changes in design after the plans and specifications were drawn. The most notable of these were: (1) The substitution of steel for wrought iron in the tank and the tension members of the tower. (2) The flanged bottom of the tank was riveted to the angle, only (Fig. 6), instead of being riveted to the top of the girder, on both sides of the web. (3) The girder was changed from a continuous web for the whole circumference to construction in segments, riveted together at the ends by means of vertical angles. (4) The tank was anchored to the tower by eye-rods. One of these rods is shown in Fig. 3, while Fig. 5 shows one of the lugs, by means of which the eye-bolt was attached to the side of the tank. (5) The butt straps covering the radial joints were placed on the outside, instead of the inside, of the bottom of the tank.

Turning now to explanations of the cause of

FIG. 4. VIEW OF WRECKED TANK LOOKING SOUTH, SHOWING HOLE ERODED IN FOUNDATION AND FOOT OF SUPPLY PIPE IN PLACE.

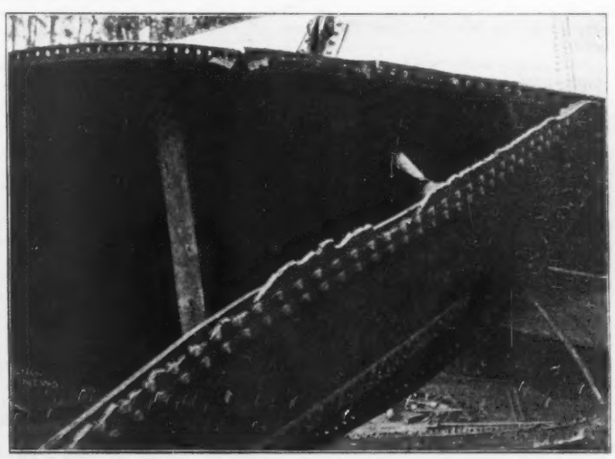


FIG. 5. PORTION OF UPPER RING OF CONICAL-SHAPED BOTTOM, SHOWING TEAR THROUGH COVER PLATE; LOOKING N. W.

failure, it appears to us that the elliptical-shaped hole in the concrete foundation pavement, shown in Fig. 4, the fact that falling water was the first alarm to the several eyewitnesses, and the further fact that the cylindrical portion of the tank is intact, indicates that the failure was primarily due to a rupture in the bottom of the tank, at the junction between the spherical-shaped plate and the inner ring of plates connected to it.

The jet of water thus released under a head of about 40 ft. struck the pavement, 100 ft. below, like a stream from a huge nozzle, and in a very few seconds, probably, tore out the hole seen in Fig. 4. The rupture then extended up the radial joints, and the whole body of water in the tank was released. As the pieces into which the bottom separated were wrenched out, either these pieces of metal, or else the large volume of falling water, caused the supporting tower to give way, and it fell with the tank. In falling, the reaction of the escaping water turned the tank half-way round, and may also have aided in throwing it to the west side and south front. In the same way, the force of the escaping water threw to the front the large section of the bottom that now rests on the foundation.

Two other theories concerning the original point of failure have been advanced, each by persons familiar with the design and construction of the structure. One is that the supporting girder was pushed outwards at a joint, leaving the bottom unsupported, and resulting in the failure of the rivets which secured it to the angle, whereupon the tears in the radial joints occurred. The other theory places the whole responsibility upon the connection between the bottom and sides of the tank. Coupled with this theory is an assertion that the tank could never be filled to a depth of over 30 ft. without straining this joint, and causing leaks. Accordingly, the catastrophe is attributed to the continued weakening of the metal at the flange, which was riveted to the angle attached, in turn, to the side of the tank.

As stated in our last issue, the tank was designed by Mr. Freeman C. Coffin, M. Am. Soc. C. E., of Boston, Mass., under the direction of the late M. M. Tidd, whose assistant Mr. Coffin then was. The contract for construction was let to Riter & Conley, of Pittsburg, Pa. Mr. Joseph K. Nye, President and Superintendent of the Fairhaven Water Co., represented the company during construction. We are indebted to Mr. R. C. P. Coggeshall, Superintendent of water-works, at New Bedford, Mass., for the photographs from which our half-tones were prepared. The photographs were taken by Mr. E. Paul Tilghman, of New Bedford.

CORROSION OF STEEL RAILS BY SEA WATER IN TROPICAL COUNTRIES.

By J. W. Post.*

In the paper on steel rails by the late Mr. Bricka (Engineer-in-Chief of the State Railways of France), of which I gave a review at the Sixth Session of the International Railway Congress (Eng. News, March 7, 1901), it is stated that the destructive action of sea water on steel rails is only obvious in the case of tracks in the immediate neighborhood of sea water, especially in tropical countries. There were no other definite data concerning this point presented to the Congress.

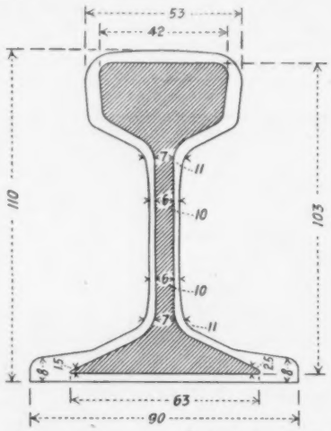
Referring to Mr. Bricka's remark, Mr. Delprat, Chief Engineer of the Sumatra State Ry., has sent me a curious specimen in the form of a piece of rail which during 10 years has been exposed more or less to sea water. The track from which this rail has been taken, lies along a quarry in Port Emma (Sumatra), not much above ordinary high tide. A sidetrack is placed on a breakwater and its rails show the same phenomena of rust. The accompanying cut shows the section of the rail when new, and also after 10 years' service. The following table shows the reduction in dimensions and in weight:

	New.	Old.	Reduction.
Head	53 mm.	42 mm.	11 mm.
Web	10 to 11 mm.	6 to 7 mm.	4 "
Flange	90 mm.	63 mm.	27 "
Height	110 "	103 "	7 "
Thickness, flange, left	8 "	1.5"	6.5"
Thickness, flange, right	8 "	2.5"	5.5"
Section	32.7 sq. cm.	19.1 sq. cm.	13.6 sq. cm.
Weight, per meter	25.7 kilos.	15 kilos.	10.7 kilos.

*Divisional Chief Engineer; Netherlands State Railway Co.

As the width of flange had decreased by more than an inch, the fastenings did not hold the rails. The inertia moment of the rusted rail section does not suffice to resist the maximum wheel load of 5 to 6 tons, which the new rail carries easily.*

The decrease of weight is about 1 kilogram per meter per year, or about 4% of the weight when new.† This confirms the impression obtained by Mr. Bricka.



Rail Section of the Sumatra State Railway, Showing the Effect of Corrosion by Sea Water in 10 Years.

(One-half Scale; Dimensions in Millimeters.)

It, therefore, seems advisable, especially for tropical railways and tramways, to use heavy rails with thick flanges for such tracks as are exposed now and then to the direct action of sea water, as has long since been done in most countries for tracks in long tunnels. It might, perhaps, pay to paint such rails with lead or a similar protective coating.

RAILWAY ROADBED CONSTRUCTION is being made a subject of investigation by the Roadway Committee of the American Railway Engineering and Maintenance of Way Association. In addition to the questions of width and crowning of the roadbed, the committee will consider the adjustment of grades with reference to tonnage rating, and has issued a circular asking for individual practice in the use of momentum grades, the methods of fixing the tonnage rating or locomotives, and also the methods of finding the equivalent values for empty and loaded cars for the tonnage rating. In regard to compensation of grades for curvature, inquiry is made as to whether the compensation should be directly proportional to the degree of curve or should vary in amount per degree on different degrees of curves. In connection with the practical work of construction, inquiry is made as to methods of carrying out steam shovel work, depositing and spreading ballast, and methods or building embankments. Particular attention will be given to forms for steam shovel records and the methods and cost of a steam shovel and other work in grade reduction under traffic. Copies of the circulars may be obtained from the secretary of the association, Mr. L. C. Fritch, 1562 Monadnock Block, Chicago, to whom also all information should be sent.

THE FIRST STATE IRRIGATION CANAL to be constructed under the Carey arid land grant act, passed by Congress in 1894, was opened a few weeks ago. It is known as the Dearborn Canal, and is designed to irrigate a large tract of land about 50 miles north of Helena, Mont. The portion of canal already completed is 12½ miles long, 5 ft. deep and 16 ft. wide at the bottom. It is a continuation af a canal 4½ miles long, 5 ft. deep and 20 ft. wide on the bottom, built by private enterprise about ten years ago, but now owned by the State. From the lower end of the new section of canal water will flow through the bed of Dry Creek for about five miles. Work is also in progress below the creek section of the canal system. A large reservoir is to be started next spring. The contractor for all the work, completed, in progress and prospective, is the Mississippi Valley Trust Co., of St. Louis, Mo. The contract price is $400,000. This is to be met by bonds, which are a lien on the land to be irrigated. The engineer for the company is Mr. John A. Knox. The interests of the State are in charge of the State Arid Land Grant Commission. Mr. David A. Cory is secretary, and Mr. Geo. T. Wickes is engineer of the commission, the office of which is at Helena, Mont. We are indebted to Mr. Cory for the information from which this note has been prepared. It may be added that the cost of this work is to be ultimately borne by settlers on the land being reclaimed. These settlers are allowed to purchase land and water rights on easy terms. They will be assessed to meet the maintenance charges of the irrigation system.

*These rails have not been used for some years. For a track exposed to regular traffic the oxidation of the rails might have been somewhat less.

†The Samarang-Joana Steam Tramway Co. (of Java) states in its annual report for 1900 that a considerable number of rails had to be renewed in the harbor tracks at Samarang, on account of corrosion or rust, especially of the rail flanges.

A PONTOON DRAWBRIDGE is being used at Milwaukee during the construction of the new trunnion bascule bridge over the Milwaukee River at Grand Ave. The temporary foot bridge has trestle approaches and a trestle built on a scow 75 ft. long and 20 ft. wide. The walk is 10 ft. wide, and hinged aprons make close connection between the fixed and movable sections when the bridge is closed. A pivot pile is placed against the downstream side at one end, and an anchor pile for the operating rope below, while a bumping pile is placed on the upstream side at the other end. Two hand hoists or crabs are on the deck of the scow, and one rope is hauled in as the other is payed out. An iron chain is used on the upstream side, as this crosses the channel, so that it will sink to the bottom and not get caught in ships' propellers. A rope is used on the downstream side. The new bascule bridge is being built by the Wisconsin Bridge & Iron Co. of Milwaukee.

A CONCRETE-AND-STEEL OFFICE BUILDING is being built in San Juan, Porto Rico, by Mr. Evert P. Maule, engineer and contractor. The structure is four stories high; and the walls are made of Portland cement concrete, built in place in wooden molds, and they are 14-ins. thick with a 6-in. air-space in the center. These concrete walls are firmly tied together in all directions by twisted steel members, placed 3 ft. apart, and bolted together at all intersections. The ground-floor will be tiled, and the other floors are to be made of wood; the stairs will be iron with marble treads, and the roof will be slate. The steel work is furnished by the Milliken Bros., of New York, says the "San Juan News," from which this item is taken.

CHERT ROADS have been used for several years with fair success at Cairo, Ill. The chert is obtained from a deposit near Elco, Ill., on the Mobile & Ohio R. R., 24 miles north of Cairo. It is chalk-white in color and compacts well under traffic, while a small amount of clay found with it acts as a binder. At Bloomington, Ill., roads made from this material have given trouble through the sticky mud being carried onto the road surface and drawing the stones from their place. At Cairo the natural soil is a sandy loam which is not sticky when muddy and the same trouble has not been experienced. We take the above information from an article by Prof. I. O. Baker, M. Am. Soc. C. E., in the "Daily Gazette" of Champaign, Ill.

TECHNICAL EDUCATION IN GREAT BRITAIN cost the government $4,575,670, says the Blue-book for 1899-1900. But no information is given as to the manner in which this money was expended, nor as to the return obtained.

FOREIGN ATTENDANCE AT THE MUNICH TECHnical College has, as at Berlin, caused the promulgation of orders intended to protect native German students. In consequence of a ministerial decree, registration for foreigners did not open until Oct. 28, two weeks after that for native. As seats in the lecture rooms and places in the laboratories can be appropriated by prospective students only after registration, this ruling gave the first choice to natives and prevented the great press of foreigners from crowding out any Germans desirous of attending.

THE MANHATTAN RAILWAY CO., in its annual report for the year ending Sept. 30, says that it carried 10,000,000 more passengers than in 1900, and the net income of the road amounted to $2,444,091, an increase of $377,312 over the previous year. The gross earnings were $10,455,872, and the operating expenses were $5,328,649; deducting from the net earnings of $5,127,223, interest on bonds $1,800,680, and $873,451 for taxes, leaves the net income given. Including all taxes the operating expenses were 59.32%; or 50.97% without taxes. The report states that the buildings for the central power stations at East 74th St. and the substations are completed and they are being equipped with machinery. The engineers expect to run the first train by electric power on the Second Avenue line in December next, and to run other lines thereafter as fast as the equipment can be assembled and put into operation. New cars to the number of 300 are being delivered.

THE NORDENSKJOLD ANTARTIC EXPEDITION sailed from Gottenburg, Sweden, on Oct. 16. The expedition is commanded by Prof. Otto Nordenskjold, a nephew of Baron Nordenskjold, and will work in conjunction with the British and German expeditions now in the Antartic regions. The Swedish ships will explore the region south of the Atlantic Ocean, while the British take the region

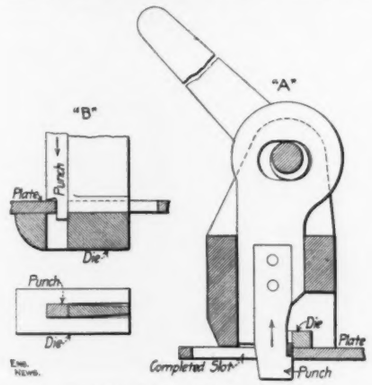
south of the Pacific, and the Germans that south of the Indian Ocean. Prof. Nordenskjold expects to push as far south as possible and to winter with five companions in a building constructed for the purpose. His ship will return to Tierra del Fuego and conduct researches in that little-explored country.

AN AMERICAN EXPOSITION IN LONDON is to be held at the Crystal Palace from May to September, 1902, under an advisory committee headed by the Lord Mayor of London. The exposition is designed to demonstrate the recent commercial development of the United States. For details and particulars of space application should be made to Alfred H. Post & Co., Produce Exchange, New York city; Mr. Post is the Commissioner for the United States.

THE TENEMENT HOUSES OF NEW YORK CITY, or rather Manhattan and The Bronx, number 45,000; and of the 160,000 dwelling houses in the city only 15,000 are occupied by a single family. In this classification New York is exceptional among the other great cities of the world. The last Federal census gives Manhattan and The Bronx a population of 2,050,000, and the tenement population is 1,550,000, an average of nearly 35 to a dwelling house. There are still 6,000 frame buildings in Manhattan and 20,000 frame buildings in The Bronx. Brooklyn is not included in this classification.

A PORTABLE PLATE-SLOTTING MACHINE.

A device for economically producing slots or irregular holes in plates of large dimensions has been invented in Germany, and is described in "Schiffbau." At present, such slots must be cut by hand, with hammer and chisel, whenever the



A Portable Plate-Slotting Machine.

plate exceeds in size the capacity of the punching machise available. Even when a machine can be used, and punches of the proper shape are at hand, the trouble of handling often makes a hand tool very desirable. The principle of the new device is shown in the figure, as applied in two slightly different ways. The essential feature is the construction of punch and die in one mechanism, so that they can be moved relatively to each other by means of a lever. In the construction shown at A the die rests on the plate, while the cutting tool projects through the plate in the finished portion of the slot. A lever raises the cutter and removes a chip from the plate in the same manner as a punch, and, after again lowering the cutter, the whole instrument can be moved forward the thickness of the chip and the whole operation repeated. In the construction B, the cutting tool acts downward, and the die is below the plate, connected to the other parts of the machine by a narrow section passing through the slot already cut. In other respects the action of B is similar to that of A. The principle of the device can evidently be worked out in a number of different forms. The construction is covered by German patent No. 115,225, granted to the firm of C. Senssenbrenner, of Duesseldorf.

THE MINING ENGINEERS IN MEXICO.

(Editorial Correspondence.)

Chihuahua, Mex., Nov. 6, 1901.

It is 8 p. m., and this is the first time your correspondent has had an hour to write notes of the trip of the American Institute of Mining Engineers. There are now 165 of us, about half of them being ladies, and we fill two special Pullman trains. The first section left New York on Friday, Nov. 1, at 2 p. m., via the Pennsylvania Ry., taking on additions to the party at Philadelphia, Harrisburg and Pittsburg. We arrived at Chicago at 3 p. m. on Saturday, one hour late, and had seven hours to stay there. Many of the party availed themselves of the invitation of the Technical Club to make use of its rooms during our stay. At 10 o'clock the two sections, each of eight cars, left by the Atchison, Topeka & Santa Fe Ry. for Mexico.

The trip on the train was very enjoyable, but not eventful. A description of one of our trains may be of interest. First, there are two baggage cars, one of which is used as a commissary for the dining car and as a sleeping car for the crew, and the other is piled full of our baggage. The latter is the source of all our woes, for our instructions say frock coats for afternoon receptions, dress suits for evenings; light clothes for warm weather and heavy clothes for cold. Next comes a dining car, then two of the latest style corridor cars containing only staterooms and drawing-rooms, the former having two berths and the latter, two berths and a lounge; a combination Pullman car, with two drawing-rooms, two staterooms, and twelve ordinary sections; the private car Olympia, occupied by President Olcott and several of his friends, and finally what is called the "stag" car, containing eight sections in the front half and a smoking room, furnished as a parlor, in the rear half. The car also has a bathroom and a commodious covered observation platform. The whole train forms the most sumptuous accommodation for traveling by rail that can well be imagined. The cars are the latest products of the Pullman company, and some of them are just out of the shops. The service is perfect, and the table is the best that the market can afford, all specially selected by Mr. Dwight, Assistant Secretary of the Institute, who is acting as manager of the excursion. When to our luxurious appointments is added the charm of agreeable companionship, what more can be asked.

Only one thing of interest to engineers was noted on the trip from New York to Chicago, viz., the vast amount of work that is being done on the Pittsburg, Fort Wayne & Chicago Ry. in the States of Ohio and Indiana, in double-tracking the line and in reducing the grades. The work seems to be in progress for a couple of hundred miles, thousands of men being employed, with steam shovels, construction trains, etc. Small grades of apparently not over five ft. to the mile are being done away with so as to make the line a dead level, and the new track is being laid with heavy rails, well ballasted.

The Atchison, Topeka & Santa Fe Ry. runs 1,630 miles from Chicago to El Paso, crossing Illinois, a corner of Iowa, Missouri, Kansas, a corner of Colorado, New Mexico, and a very small piece of the extreme western corner of Texas. The track is excellent as far as Colorado, and very fair the rest of the way. Our schedule time for the run was 42 hours, or about 39 miles per hour, including stops, but some hot boxes at the beginning of our run made us two hours' late at Kansas City, and we lost our right of way and had to fall behind a regular train, so that our actual running time was 48 hours, and we entered Mexico, at Cuidad Juarez, six hours' late. We were not much troubled by the custom house, as the officers had apparently received orders to give our baggage only a superficial inspection, and the trunks were not taken out of the cars.

The run from Cuidad Juarez to Chihuahua is 227 miles, and it took about eight hours to make the run, or an hour more than the schedule time. Our two trains are said to be the heaviest that ever entered Mexico, and rather beyond the capacity of the locomotives. The country is all high table land, approximately level, with low ranges of mountains on each side at a distance of from 10 to 30 miles. It is very monotonous scenery, and most of it is too barren even for grazing. The railroad has only 26 stations in the whole distance, some of them having only one or two houses, surrounded by wretched-looking mud huts.

We arrived at Chihuahua at 7 p. m. During the afternoon we were informed that we must dress in our frock coats for the formal reception by the Governor of the State of Chihuahua at the palace, to which we would be taken in carriages immediately on arrival, and that we would afterwards be brought back to the train for supper, and to dress in our swallow-tails for the grand ball which was to open at 10 p. m. This programme was followed to the letter. The work of getting at our trunks in the baggage car will never be forgotten by those who participated in it. As only two or three people could find room at a time in the narrow passage between the trunks, they had to be piled and repiled over and over, and usually each newcomer into the baggage car found his trunk at the bottom of a pile. The sleeping car sections were draped with curtains, and thus converted into dressing rooms. Finally the dressing was accomplished and we were all ready for the carriages when the train entered the station.

We found the palace a magnificent building, beautifully furnished. A military band played our own national airs in our houor, and after we had all arrived in the reception room the Governor, Miguel Ahuhamada, with his wife and an interpreter, entered the room, and made a speech to us in Spanish, which was replied to by our President, Mr. Olcott, also in Spanish. After this each member of the party was presented to the Governor and welcomed with a shake of the hand. The Governor is a most imposing personage, about six ft. three in height, and of a most amiable appearance. He is one of the most important men in Mexico, and is now serving his third term as Governor. After the formal reception, we entered another room, where a light luncheon with champagne was served.

The ball was held in the Theatre of the Heroes, a splendid building, close by the palace. It was a brilliant affair, and to our eyes the beautiful senoras and senoritas were its principal attraction. Dancing began promptly, and was continued till a late hour, many of our party not returning to the train till 3 a. m. A supper was served at midnight, with Mexican dishes to which the palates of our party were not accustomed, but the wine was good, being French and German.

The morning of the next day, Wednesday, was spent in viewing the town, under the direction of several English-speaking Mexican guides. As few of us had ever before been in Mexico; it was full of surprises. The general verdict was that it is more foreign to us than anything in Europe, and it was compared to Palestine and Egypt by those who had been in those countries. In the afternoon a bull fight was given in our honor. Perhaps it was wrong to go, according to our American notions, but we all went, to satisfy our curiosity. After the killing of the first horse, which happened early in the first of the three fights many of our ladies kept their eyes riveted to the ground, refusing to look again into the ring. The audience numbered about 4,000, and the fight took place exactly as it is described in the guide books, although the Mexicans said it was a poor one, as the matador and the banderilleros made many unskilful plays.

Among the things of interest to engineers in Chihuahua is the aqueduct which brings water to the city, and the new plant of Jewell filters, by which the water is purified. Alum is used as a precipitant, and the plant appears to be a great success. There are no pumping engines, the supply being a gravity one.

Some of the party visited La Describedora mine, known as the manganese mine, a few miles outside of the city. The ore carries $6 gold and 10 to 14 ounces of silver to the ton, and also contains 18% of manganese, 2% of iron and 15 to 20% silica, while the balance is carbonate of lime.

Our whole experience at Chihuahua has been full of interest, and the hearty welcome we have received from the Mexican augurs well for the success of the remainder of the trip. We leave at midnight for Parral, where we are to have another reception and visit mines in the vicinity.

Mexico City, Nov. 9, 1901.

In a programme of the visit to Chihuahua, printed by the local committee, credit is given to the members of the American Institute of Mining Engineers for the valuable aid and impetus recently given to the mining industry of Mexico, "making it possible to reap fortunes from mines which for years have lain dormant for lack of proper methods of treatment." * * * * "To their resourceful and exhaustive examinations may be traced the opening and operation of valuable properties which are now making Chihuahua famous among the mineral producers of the world."

Chihuahua is the capital of the largest State in the republic. It has a population of 35,000. It was founded early in the 17th century by Spaniards, who worked the mines in the neighborhood, some of which have been worked for 300 years, and are credited with an output of $2,000,000,000. The annual product of the mines of the State of Chihuahua is now over $10,000,000 of gold and silver bullion alone, besides $3,000,000 worth of ores annually exported for treatment. Sixteen principal mining camps are named, in the pamphlet of the local committee, where operations are now in progress, and many others are said to await only the construction of the Kansas City, Mexico & Orient Ry. to contribute largely to the output of the State. Several large companies have been organized within the past six months to work the recently-discovered ores of the Santa Eulalia district.

PARRAL AND SANTA BARBARA.—We reached Parral at 11 a. m., Thursday, Nov. 7, three hours' late, as usual. Our reception was of the most extraordinary description. A thousand or more peons with their wives and families surrounded the station, making with their enormous hats and curious dress a most picturesque sight, and one which was taken advantage of by our camera fiends. Through this mob we were piloted by the local committee across a street to the "Bodega," a large warehouse, which had been emptied, plastered, kalsomined and decorated with flags and with colored papers in our honor. On entering we had to run the gauntlet of a score of dark-eyed senoritas, who pelted up with confetti, while a band played "The Star-Spangled Banner." A handsomely printed pamphlet, containing a description of the Parral and Santa Barbara district, with many photographic views, was handed to each of the guests. Three long lunch tables, seating about 300, were spread with good things, of which the most noticeable were boxes of fine strawberries. The lunch was not taken at this time, being postponed until our return from the mines, but a speech was made to us

in Spanish, to which our President responded in the same language.

The programme of the day gave us our choice of two trips, one over the narrow-gage Parral & Durango Ry. to Minas Nuevas, a few miles distant, and the other to Santa Barbara, the present terminus of a short branch of the Parral Branch of the Mexican Central Ry., 15 miles from Parral.

Santa Barbara was founded in the year 1547. In 1580 it was the seat of the Spanish Viceroy, whose territory at that time covered Northern Mexico, and what is now the western part of the United States, including California. It contains the oldest mission church in the whole of that extensive region. Two years ago its population was only 500 people, now it has 5,000, the rapid increase being due to the completion of the railroad, the reopening of several mines and the construction of new concentrating works. A large proportion of the population live in the most primitive style, in huts built of mud, of thatched branches of trees, and in some cases in tents made of old corrugated iron taken from some old buildings of the mining companies.

Here at Santa Barbara can be found the old and the new in civilization, and the contrast between wealth and poverty in closer juxtaposition probably than in any other part of the world. There is a new concentrating works, fitted with the most modern machinery, in operation only two months, a fine new hotel, built this year, owned by Mr. Mackey, who came here from Montreal 18 years ago, and to whom is due the recent introduction of American capital into the district, and a fine railroad station, not quite finished. There is a peon here who a year ago was working for $1.50 per day, Mexican money, and who is now making $50,000 a month from a mine he located, while hundreds of other peons are bringing up large families in mud huts on $1.50 a day, which is probably the highest wage paid to common labor in any mining camp in Mexico. There is a compound surface-condensing Corliss engine in the mill, and alongside of it women grind their corn by pounding it in a stone mortar, as was done thousands of years ago.

In the 16th century Santa Barbara had a population of 7,000, and there were reported to be as many as 700 "arrastras" at work for treating the gold ores, but an exodus took place to Minas Nuevas, and Santa Barbara was of no importance until the early part of the 19th century, when, for a short time, one of the mines was operated, and shortly afterward abandoned. The present revival dates only from 1892, when $80,000 was extracted from the old mine.

The new concentrating works above referred to is known as the La Cruz mill of the Montezuma Lead Co. Its concentrates are shipped to the smelter of the same company at San Luis Potosi. Its capacity is 300 tons of ore per day. Another mill, of 400 tons capacity, is now under construction by the Guggenheim Co. The ores are of low grade, but they exist in enormous quantity.

The pamphlet issued by the Parral committee gives a list of 33 "historical mines" in the Parral district, and of six reduction works near Parral, viz., four lixiviation, one patio process, and one concentrating, besides one lixiviation and one amalgamation works at Santa Barbara, and the two new concentrating works already mentioned. The largest of the old works has a capacity of 80 tons per day.

On returning to Parral about 4 p.m., the tired and hungry party had luncheon, more speeches and music, and returned to the train, while the band was playing and the Mexican girls, who lunched with us, sang the national hymns. Thus ended a most delightful day.

Our train left Parral at 8.30 p. m. and reached Zacatecas at 4 p.m. the next day. We saw some fair scenery on the road in the afternoon, as we climbed to an altitude of about 9,000 ft. before running down into Zacatecas, altitude over 8,000 ft. There was no reception committee at this place, and the person who is acting governor, in the absence of the governor, even refused to receive a visit of courtesy from our president, a notable exception to the treatment we have received everywhere else in Mexico. However, we found several rickety tram cars at the station, each drawn by three frisky mules, and on them we made the journey of a mile or more through the quaint old town to the market and the cathedral. We found a few guides, notably the agent of the Wells Fargo Express Co., who conducted us on foot through the town, visiting the mint, the old cemetery, in which the graves are tombs above ground, the jail, a bad smelling place, and another cathedral. A small party visited one of the mines adjoining the town.

Zacatecas is the most finished city we have thus far seen. It dates back to the middle of the 16th century. The houses are of stone, one-story high mostly, and the streets are paved with cobblestones, with sidewalks of small flat stones, which often are set so irregularly that the best walking is in the middle of the street. [illegible] book gives its population at 45,000, and like [illegible] pearance to the cities of Palestine. It is in an [illegible] mineral district, said to have produced nearly [illegible] of dollars of gold and silver from 1548 to 18[illegible] there was no local committee we are in ignora[illegible] present position as a producer of the precious [illegible]

We left Zacatecas at 8 p. m., and did not reach [illegible] till 4 p.m., the next day, Saturday, Nov. 9, or [illegible] behind our schedule. The distance we have [illegible] in the eight days since leaving New York is 3,9[illegible] It has been a magnificent trip thus far, and not one of the party shows any signs of fatigue.

W. K.

65-FT. WHEEL FOR RAISING STAMP SAND.

The sand discharged as debris from the large stamp mills of the copper mines on the Keweenaw peninsula of northern Michigan has so filled up the shores of Torch Lake that in some cases, with mills close to the shore level, the sand and water have to be raised to a considerable height and discharged into inclined chutes built over the made land to the new water line. As the sand

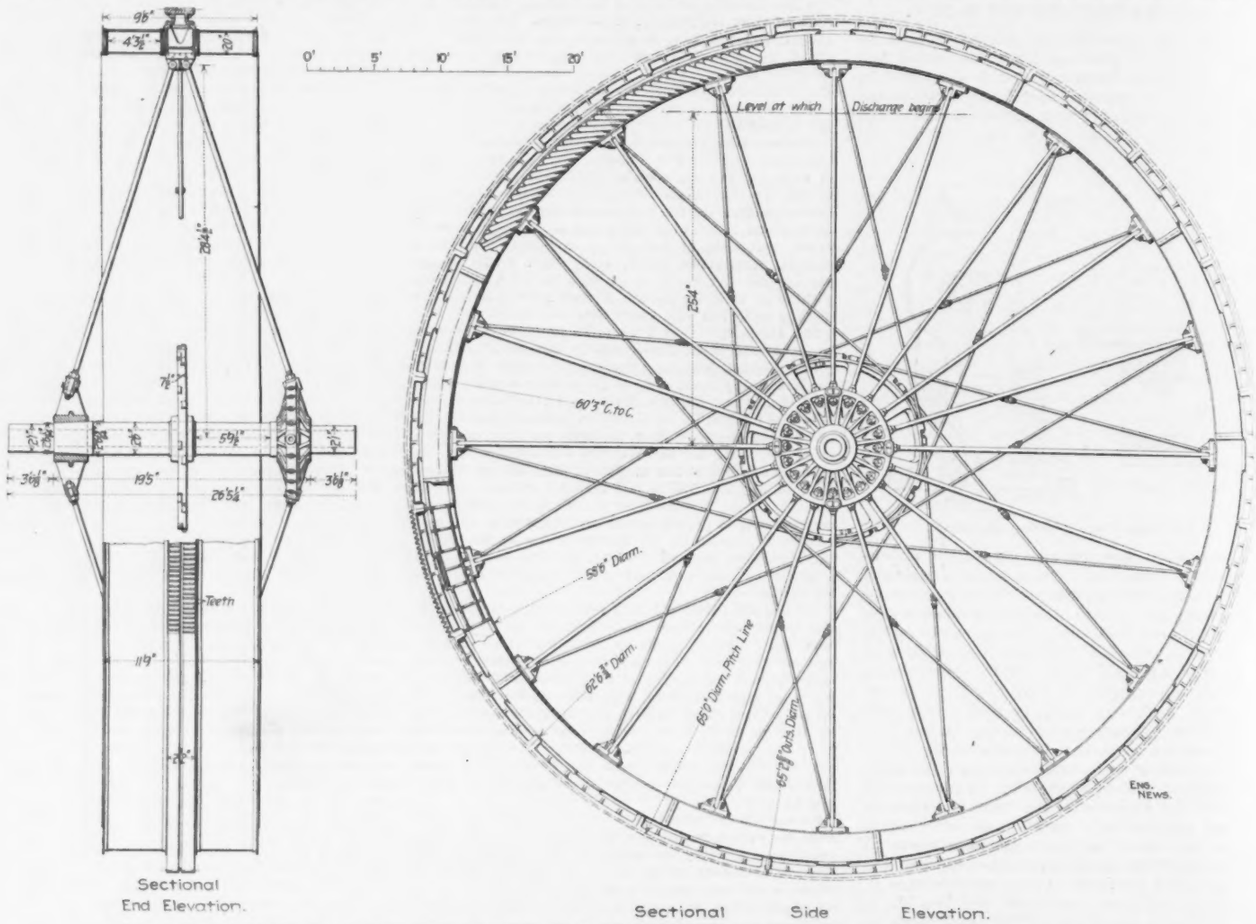


FIG. 1. 65-FT. SAND ELEVATING WHEEL FOR STAMP MILL OF THE CALUMET & HECLA MINING CO.
E. D. Leavitt, M. Am. Soc. M. E., Cambridgeport, Mass., Designer. Robert Poole & Sons Co., Baltimore, Md., Builders.

is coarse and gritty, and very hard, it cannot be pumped, and would cause rapid wear of any ordinary conveying apparatus. At one of the great stamp mills for amygdaloid copper ore of the Calumet & Hecla Mining Co., at Lake Linden, Mich., wheels 54 ft. diameter, fitted with buckets on the rim, have been adapted to this purpose; and two such wheels, 54 ft. in diameter, are now in use. These wheels are of bicycle construction, with rod spokes, and each discharges about 2,500 tons of sand and 25,000,000 gallons of water per 24 hours.

A new wheel of the same type, but 65 ft. diameter, is to be installed, and is shown in the ac-

comprising illustrations. Fig. 1 is a general drawing, while Fig. 2 shows the wheel in course of erection at the builder's shop. The shaft or axle is made of Krupp crucible cast steel, 32 ins. diameter and 27 ft. long, with a 16-in. hole bored through the center; it weighs 42,000 lbs. The journals are 25 ins. diameter and 42 ins. long. Two cast-iron hubs are fitted to either end of the shaft, each weighing 20,000 lbs., and from these hubs radiate 40 steel arms or spokes of 4-in. rolls which support the rim sections on the same principle as a bicycle wheel; each spoke is arranged with special nuts and threads for adjustment when erected in place. The rim is built up in 20 segments. It consists of two concentric rings; the one on the inside (for strengthening the entire structure) is attached to the radial spokes; the other, on the outside, consists of a toothed gear rim fastened to the inside rim with bolts and keys. On the periphery of the outside rim is cast the driving rack, with staggered or stepped teeth, and these teeth are milled with special tools to an accuracy of 0.001-in. The pitch of the teeth is 4.7 ins. Each row of teeth is 12 ins. wide, making an effective working face of 24 ins. There are 26 teeth in each segment, or a total of 520 in the entire wheel.

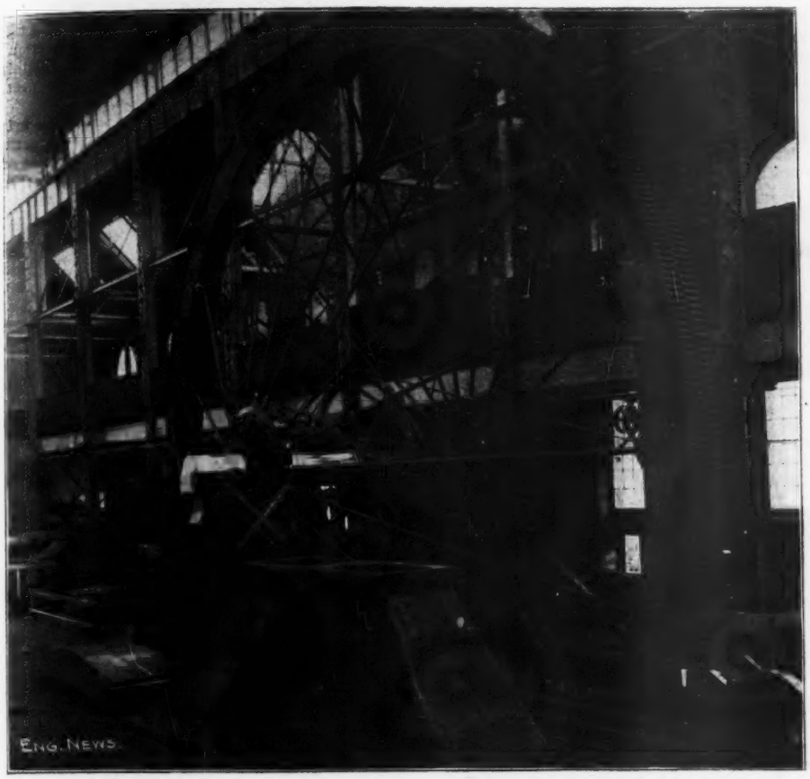


FIG. 2. 65-FT. SAND ELEVATING WHEEL PARTIALLY ERECTED IN BUILDER'S SHOP.

To each side of the sectional rim is riveted a rectangular plate iron box, carrying on its inner side 275 buckets, 550 in all, each bucket measuring 4 ft. 3½ ins. × 3 ft. 4 ins., and 20 ins. deep. The buckets are set at an angle which, together with the peripheral velocity, prevents discharge until a horizontal position is reached near the top of the wheel. The width across the face of the wheel when the buckets are fitted is about 12 ft. The lower part of the wheel dips in a shallow pit, into which flows the refuse from the stamp mills, and as the wheel turns each bucket is filled with water, gravel and sand, and carried up to be discharged at an elevation of about 50 ft. into a trough, whence it is carried away by the water in sluiceways. The pinion by which motion is given to the sand wheel is 37 ins. diameter, and has 23 teeth in each row, accurately milled to match the large wheel. It is fitted to a shaft carrying on its outer end a mortise, or wood-tooth wheel, engaging with an iron pinion fitted on the shaft of a 750-HP. electric motor, having a speed of 150 revolutions per minute. The large wheel makes about four revolutions per minute, and the peripheral speed at the inner edge of the buckets will be about 12 ft. per second.

This will be one of the largest wheels in the world, and will discharge about 75,000,000 gallons of the sand and water per 24 hours. The total weight of the wheel, including its base plates and supporting columns will be over 500 tons. It is expected that the wheel will be ready for delivery in about four months, when 30 or 40 gondola cars will be required for its transportation in sections.

The wheel is being built by the Robert Poole & Son Co., of Baltimore, Md., from plans prepared by Mr. E. D. Leavitt, M. Am. Soc. M. E., of Cambridgeport, Mass., who is Consulting Engineer for the Calumet & Hecla Mining Co. Mr. H. W. Cake is Superintendent of the stamp mill where the wheel is to be installed.

ANNUAL MEETING OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

The ninth annual meeting of the Society was held on Nov. 14 and 15 at the house of the American Society of Mechanical Engineers in New York city. The attendance was representative and the programme was carried through in a business-like manner. Practically all of the routine business was completed in the first half hour of the opening session and the entire remainder of the convention period was devoted to the reading and discussion of papers.

The first routine business was the reading of the report of the Secretary-Treasurer, Mr. W. L. Cupps, Naval Constructor, Brooklyn Navy Yard. This report showed the total membership of the Society to be 755, of which 101 were elected at the meeting of 1900. During the year 1901, 69 applications for membership were received. The finances of the Society were shown to be in good condition, although the expenditures of the current year had been slightly more than the receipts. In view of the fact a resolution was offered later in the session to the effect that the annual dues be increased. They are now only $5 for Members and Associates and $3 for Juniors. The election of officers was the next business and it resulted in the present officers being re-elected with the exception that Rear Admiral Francis T. Bowles was elected Vice-President in place of Rear Admiral Francis M. Bunce, deceased, and that Mr. D. W. Taylor was made a member of the council to fill the vacancy left by the promotion of Admiral Bowles. Immediately after the election of officers the convention proceeded to the reading and discussion of papers.

TRIAL OF SPEED BETWEEN THE STEAMERS "CITY OF ERIE" AND "TASHMOO."

This paper, by Mr. Frank E. Kirby, Naval Architect, Detroit Dry Dock Co., Detroit, Mich., described the results of a speed trial between the two steamers named which had originated in the mutual claims of superiority made by the owners and officers of the two vessels. The race took place on Lake Erie on June 10, and resulted in the "City of Erie" winning by 45 seconds over a course of 94 miles.

THE EFFECT OF VARIATION OF DIMENSIONS UPON THE STRESSES IN A SHIP'S STRUCTURE.

This paper by Prof. Herbert C. Sadler, University of Michigan, was a mathematical presentation of the subject and of questions connected with it. The discussion was too special in character to be of general value, but in view of the constantly increasing size of ocean steamships the following excerpt from Professor Sadler's paper is of general interest:

> The assumptions usually made as to the worst condition in which a vessel of the ordinary mercantile type may be placed, are that she is instantaneously poised upon the crest of a wave whose length is equal to that of the vessel, and whose height is 1-20 of that length. Observations of Lieut. Paris and others have established the fact that as the length of wave increases the ratio of height to length decreases. In waves of 300 ft. to 350 ft. this ratio is approximately 1 to 20, and up to waves of 500 ft. it seldom if ever exceeds 1 to 25, while the waves still longer, these figures may drop as low as 1 to 50. Waves greater than 30 ft. in height are not commonly encountered, and this height in conjunction with a length of 600 ft., corresponding to the ordinary assumptions as to wave height, may be considered as practicely never occurring. Hence it seems scarcely reasonable to assume that a vessel of from 600 ft. to 700 ft. long would ever be instantaneously poised on the crest of a wave of its own length, and from 30 ft. to 35 ft. in height. In the same way with regard to pitching, the probability of a vessel of this length falling in with a series of waves of the above dimensions is exceedingly remote, and decreases rapidly as the length of ship increases. Hence it is reasonable to suppose that the bending moment upon a vessel will not increase as the fourth power of the dimensions when the larger size is reached, and, as will be shown later, will vary more nearly as the cube of the dimensions.

There was no discussion on this paper. The next paper was read by Mr. Frank M. Leavitt, Mechanical Engineer, Brooklyn, N. Y., and described a series of tests made to determine the power consumed in propelling the Whitehead torpedo at various speeds. An abstract of the paper will be published in a future issue. The next two papers were those submitted in competition for the prize of $100 offered for the best paper on "Theoretical and Practical Methods of Balancing Marine Engines." Before these papers were read the chairman announced that a number of papers had been received in this competition, and that of these two were of such excellence that it had been something of a problem to decide between them. It had been finally described to award the prize to the one which it was afterwards learned had been presented by Naval Constructor D. W. Taylor, of Washington, D. C., but to recognize the almost equal value of the other by awarding it a special prize. The special prize paper it had been found afterwards was presented by Admiral Geo. W. Melville, Engineer in Chief, United States Navy. The two papers were elaborate mathematical discussions of the problem and constitute extended monographs of unusual technical value on the subject treated; their length and character make it impossible to present them here. The discussion which followed consisted almost entirely of remarks in commendation of the work done by the authors of the two papers.

A BRIEF COMPARISON OF RECENT BATTLESHIP DESIGNS.

This paper, by Naval Constructor H. G. Gillmor, was an attempt to determine the relative naval value of six recent battleships, built by different nations. The designs chosen were Great Britain, the "Duncan;" Germany, the "Wittelsbach;" Russia, the "Borodino;" Italy, the "Vittorio Emanuele;" Japan, the "Mikasa," and the United States, the "Virginia." In each case there are represented two or more vessels, the naval features of which are virtually the same as that of the vessel named. The information available with respect to the latest French battleship design was so meager as to have made it impracticable to include it in the comparison proposed. A brief description of each of the chosen vessels was given, and then the paper continued as follows:

> The variations which have been pointed out make direct comparison of the several vessels difficult. To establish a basis for the present comparison, it is proposed to assume a vessel whose dimensions are those of the largest vessel under consideration, in which the features of armament, protection, speed, and coal supply embodied are the minima of these several features, which may be found among the designs under discussion. Such a vessel would represent the extreme limit to which, as judged from current practice, it is thought possible to reduce the several elements, and will be designated a type design.
>
> Such a vessel as the type design outlined above has, for naval purposes a definite value, which might be expressed in a variety of ways. Each of the several vessels whose designs it is proposed to compare may be regarded as being

such a vessel as the type design, upon which improvements of value have been introduced in one or more of the elements of armament, protection, speed, or coal supply. The designers of the several vessels under consideration, having provided for the minima of the several essential features of battleship design, have varied the distribution of the remaining disposable weight in a manner which each individually deemed most efficient. Since each of the several features may be found developed to an extreme in some one or more of the vessels being compared, and since the one restricting and governing condition in such development is weight, may it not fairly be assumed that the naval value, assignable to the excessive development of any one of the design features, may be represented by the weight necessary to such a development in any degree above that represented by a minimum embodied in all the designs. Such an assumption will here be made; and the naval value of the type design will be assumed to be 4,300 the approximate weight required, under the conditions outlined, to provide in the type design the features embodied. The relative naval value of each vessel under consideration, as compared with the type design, will be expressed finally by adding to 4,300, the naval value of the type design, the weight which it would be necessary to add to the type design in order to provide in that vessel for the armament, armor, speed, and coal carried in the design whose relative naval value it is desired to represent.

Based on this reasoning the paper gave the relative naval value of the six vessels named as follows: "Virginia," 7,050; "Duncan," 6,300; "Borodino," 5,790; "Mikasa," 6,730; "Vittorio Emanuele," 6,560; "Wittelsbach," 5,260. The paper then continued:

Since the relative naval values given above are expressed in terms of, mathematically, the same dimensions as those employed in the expression of displacement,—if the relative naval values be divided by the designed displacements of the several vessels, the results may be expressed as a percentage, which might be termed the efficiencies of the several designs. The order of merit of the designs would be, on this basis, as follows: "Vittorio Emanuele," 52.0. "Virginia," 47.2. "Duncan," 45.0. "Wittelsbach," 44.6. "Mikasa," 44.3. "Borodino," 42.7.

The succeeding papers were: "Changes in Torpedo Boat Design," by Charles P. Wetherbee; "Late Developments in Ordnance and Armor," by J. F. Meigs, and "Recent Experiments in Attacking Armor with High Explosive Shell," by E. B. Babbitt. The two last are printed in abstract in another column of this issue. The two following papers: "Some Notes on Tidal Corrections," by Edwin A. Stevens, and "Side Launch of Torpedo Boats and Torpedo Boat Destroyers," by Assistant Naval Constructor, W. G. Groesbeck, were too special in character to be published here. They were not discussed.

A HIGH CHIMNEY FOR DISCHARGING ACID VAPORS.

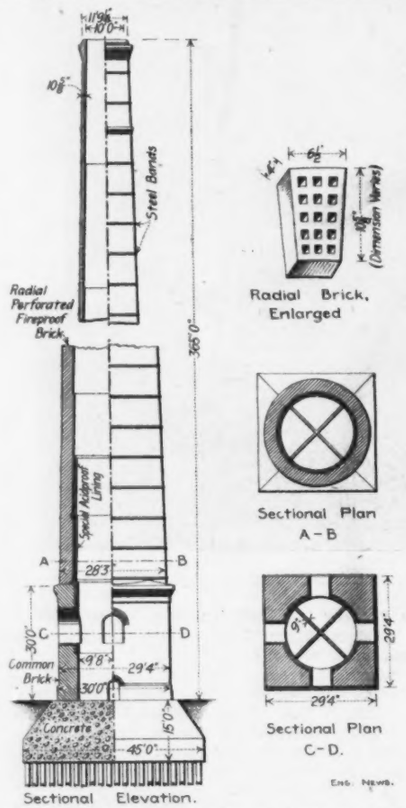
A chimney has been erected during the past year at the works of the Orford Copper Co., Bayonne, N. J., which ranks among the tallest in the world, rising to a height of 365 ft. above top of foundation. The chimney was built to meet some special conditions. A large quantity of gases required to be disposed of; these gases were strongly acid in composition, and required to be lifted to a great height that they might be dispersed without nuisance to the surrounding property. To make a permanent structure demanded, on account of this acidity of the flue gases, that the materials used be far more resistant than those ordinarily employed in chimney construction. The builders of the stack, the Alphons Custodis Chimney Construction Co., New York city, solved the problem with a chimney constructed of brick of special composition, having high acid and fire resisting qualities. It may be mentioned here that the difficulties of the problem were greatly increased by the fact that only soft, marshy ground, extending to considerable depth, was available for the foundation of the structure.

The chimney, as constructed, is shown in the accompanying figure, where the principal dimensions are also given. The portion from the top of the foundation to the line C C constitutes the base of the chimney. It is constructed of a good quality of ordinary hard-burned red brick, with a lining as indicated by the darker shaded section. The smoke flues enter the chimney in the middle of the four sides, being lined similarly to the base itself. To prevent back pressure in any one of the flues from any of the others, the lining is carried diagonally across inside of the chimney in two partitions 9 ins. thick, extending from a little below the flues to the top of the base, forming a separate uptake pocket for each flue.

Above the base, which is 30 ft. square at its largest point and 30 ft. high to coping, rises the shaft of the chimney itself. This shaft is circular in form, tapering from an outside diameter of 28 ft. 3 ins. to 11 ft. 9¼ ins. The wall thickness decreases from 46 ins. just above the base to 10⅝ ins. at the top. For 34½ ft. upward from the base the chimney has a lining in continuation of that of the base, leaving an air space of about 2 ins. between it and the outer wall. At intervals of about 8 ft. the brickwork of the stack is tied around with hoop iron. This is a precaution adopted mainly to guard against damage in case of explosion of gases within the chimney; its wisdom was shown in this case by the occurrence of an explosion in the stack and flues within 24 hours after starting up. A ladder is built into the brick structure, both within and without. At the top the usual cast or other cap is replaced by a cornice built of brick, like those used in the chimney; one of the hoops mentioned is placed just above the cornice and ties the top securely together.

The foundation of the stack is a solid mass of concrete 45 ft. square at the bottom and extending to a depth of 15 ft. below the base; that is, several feet below low water level. It rests on and surrounds the heads of piles driven to hardpan; the piles, 360 in number, are spaced about 2 ft. on centers.

The construction of the main shaft of the chimney and the lining in the lower part offers the main features of interest. The bricks used in the main wall are of special form, having radial and circular faces to fit them as nearly as possible to the circle required, and thus minimize the thickness of the mortar joints. They have perforations running vertically through them, decreasing the heat conducting power of the stack. In laying up the circular wall with these bricks, the mortar presses into the holes some distance, and considerably increases both shearing and tensile strength of the mortar joint. These bricks are made of a mixture giving them high resistance to both the heat of the flue gases and the disintegrating effects of the weather. A perspective view of one brick is given at A in the figure. The uniform size of the outer curved face of the brick is 6½ × 4 ins. The length varies, as does the radius to which the brick is shaped, so that different thicknesses of wall can be produced on any circle. The use of the different lengths also enables the work to be most effectively bonded, producing finished work without continuous circular joint surfaces.



Vertical Section and Elevation of Stack of Orford Copper Co., Bayonne, N. J.
Alphons Custodis Chimney Construction Co., New York, N. Y., Builders.

The brick in the main shell are not as highly fire and acid proof as is required in some portions of the lining, since brick with high rank in these respects cannot be made sufficiently durable where exposed to the weather. A special brick of exceptional qualities of resistance to the effects of high temperature and heated acid fumes is therefore used as lining in the lower part of the shaft and in the flues and base where the gases come in contact with the walls. This is the section shown in black in the illustration. As shown, it is built in short sections, separated by an air space from each other and from the wall of the stack, each section resting on a shelf corbel out from the stack wall. The highly heated lining is thus insulated from the stack, and the expansion of the lining itself can readily take place. At the same time, the separate renewal of any section is possible, a feature of especial value where lining of even this special composition may be expected to have a comparatively short life.

The stack was calculated on the basis of a wind pressure of 50 lbs. per sq. ft. vertical projection, this figure being reduced for the rounding of the main shaft. The weight of the whole stack, exclusive of foundation, is about 2,528 tons; the foundation weighs about 1,980 tons. The extreme load on the pile foundation is estimated at 20 tons per pile. The cost of the stack, erected complete, was somewhat over $50,000.

RECENT EXPERIMENTS IN ATTACKING ARMOR WITH HIGH-EXPLOSIVE SHELL.*

By E. B. Babbitt.†

The struggle between the armor and the projectile is drawing to a close. The limit of flotation has practically settled the thickness of armor to be carried, and the manufacturers now bend their energies, with remarkable success it is true, to improving the armor. With all this, however, the projectile is in the lead, and has now brought to its assistance the valuable aid of high explosives.

The Ordnance Department of the Army has been experimenting for many years to secure a high explosive for a shell filler, and with varying success. In the reports of the Ordnance Board conducting these tests in 1883, 1884 and 1885, they usually concluded with "burst at the muzzle" or "destroyed the gun." Naturally, then, the problem, as it presented itself to them, was to secure an explosive that could safely be fired from a high-powered gun. As we approach it now, that is really but a corollary to the condition that it will not explode on impact on armor, as the shock in the latter case is so much greater.

When the Board of Ordnance and Fortification was organized, the tests with high explosives took a wider range, due partly to the larger fund at its disposal and partly to the increased activity of the manufacturers for a time. The subcommittee of this board considered at length this subject and reported:

It appears that the following points are to be investigated: (1) Which is the best explosive for use in shells. (2) Is an explosion of the first order, or detonation, assured with the different methods of loading proposed by the inventors to prevent premature explosion. (3) Will the explosive stand the friction due to rifled motion when loaded as proposed. (4) Will the explosive stand the shock of firing when loaded as proposed by the different inventors. (5) Will the igniting mechanism stand the shock of firing and the rifled motion without premature action. (6) Will the igniting mechanism act as desired. (7) Will the shell, without the igniting mechanism, explode on impact with water, with earth, with stone, with wood, or light iron, and with iron armor.

Considering these it appears: That the first is the summation of those that follow. The second, in its investigation, led to extensive sub-terra experiments which, while instructive, really led the investigators from the true scope, namely, to get an explosive that could be used in a shell. The third condition was quite a bugaboo, and comes to us even to-day. I have my doubts as to its importance.

In a moment of mental aberration, I devised a fuse depending for its action upon a plunger within remaining at rest while the envelope took up the rotation of the projectile. I had no doubt about this feature, but, wishing to investigate another, made such a plunger, supported, by the way, by an axial shaft, thus reducing the frictional moment, and fired it from a field gun into a sand butt. When recovered and opened—behold! the plunger had not moved in its housing. Thus ended a threatened revolution in the fuses of the world. As my brother officer, Captain Crozier, would say, "Ideas are cheap; worth about 25 cts. a bushel"—when one is developed into something tangible it is priceless.

*A paper read at the ninth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, Nov. 14 and 15, 1901.

†Captain of Ordnance, U. S. A., officer in charge of experiments at Sandy Hook proving ground.

the remaining conditions, those regarding the fuse and firing mechanism are important, since in the later development a successful explosive waited on a satisfactory fuse.

At the time of this report, 1891, there were before the board, explosive gelatine, gun-cotton, emmensite, Schwalin powder and Americanite. Of these gun-cotton alone is considered as a shell filler, and then only wet and in a matrix. Between 1892 and 1896, there were tested in addition: Terrorite (N. G. and nitro ethyl and nitro-naphthalene); rackarock, a spengle safety mixture; ammonite, 90% ammonium nitrate and 10% mono-nitro-naphthalene; jovite, 87 NH_4NO_3 and nitro-phenols and nitro-naphthalene. None met with success. Between 1896 and 1898 the Ordnance Department experimented largely with gun-cotton, in various forms and degrees of moisture, and met with considerable success, thanks to a detonating fuse devised by Lieutenant, now Captain W. S. Pierce, Ordnance Department. In 1898, Thorite began its brilliant but short career. The sensitiveness of most of the high explosives brought forth during this period many novel ideas for firing them with safety, the most notable being the famous pneumatic dynamite guns, three of which were mounted on the Vesuvius, and were used at Santiago with so little effect. As late as August 23, 1900, a charge of 129½ lbs. of explosive gelatine was fired from a 12-in. service rifle using an Isham diaphragm shell. The explosion of this mass against a 12-in. plate failed, on impact, to rupture the plate, but moved it badly. More damage was done to a similar plate with a service armor-piercing shot, uncharged.

With the reorganization of the Ordnance Board in 1899 was introduced the present system of investigation, which, in its workings, has brought about conclusive results, and has, it is thought, given a most satisfactory explosive and fuse; in other words, a most powerful weapon for attack, superior to any possessed abroad of which we have any knowledge. I can do no better than quote the following reply of the Ordnance Board to a letter from the Chief of Ordnance asking about the status of the question of high explosives for shell:

From the nature of the subject it is evident, and experience has amply demonstrated the fact, that the selection of a high-explosive shell which shall be thoroughly efficient and yet safe beyond any reasonable doubt to store, handle and fire under all conditions of service, presents a most difficult problem which offers chances of failure at every step and can be considered solved only when these requirements are satisfactorily established by exhaustive tests. The destructiveness of the explosive makes it a constant menace to the men and material using it, and a perfected projectile involves not only the explosive, but the fuse and the method of constructing the shell also.

A satisfactory high-explosive shell should fulfill the following requirements:

SAFETY AND INSENSITIVENESS.—(1) Should be reasonably safe in manufacture and free from very injurious effects upon the operatives.

(2) To warrant further test, must show a relatively safe degree of insensitiveness in the impact testing apparatus used by the department.

(3) Must withstand the maximum shock of discharge under repeated firings in the shells for which it is intended.

(4) Must withstand the shock of impact when fired in unfused shells as follows: (a) Field shell. Maximum velocity against 3 ins. of oak timber backed by sand. (b) Siege shell. Against seasoned concrete thicker than the shell will penetrate, with remaining velocity for full charge at 500 yds. range. (c) Armor-piercing shell. Against a 7-in. tempered-steel test-plate in a 12-in. A. P. shell with a velocity just sufficient to penetrate.

DETONATION AND STRENGTH.—(5) Must be uniformly and completely detonated with the service detonating fuse.

(6) Should possess the greatest strength compatible with other necessary requirements.

STABILITY.—(7) Must not decompose when hermetically sealed and subjected to a temperature of 120° F. for one week.

(8) Should be preferably non-hygroscopic, and must not have its facility for detonation affected by moisture that can be absorbed under ordinary atmospheric exposure necessary in handling.

(9) Must not attack ordinary metals used in projectiles and fuses to an extent that cannot be prevented by simple means.

(10) Must not deteriorate or undergo chemical change in storage.

GENERAL CONDITIONS.—Loading must not be attended with unusual danger, and should not require exceptional skill or tedious methods. It is very desirable that the explosive be capable of compact loading, either by melting or compressing into solid blocks. It should be possible to procure the explosive quickly and in quantity in this country at a reasonable cost.

To carry out investigations covering all these conditions involved constructing a comprehensive scheme of test and the expenditure of much money. The object being to get the explosive through armor, the final test would naturally be a practical trial under service conditions. These costing from $3,000 to $5,000 per round could be very few, and means had to be devised for an early elimination of those doomed to failure.

We, therefore, first determined: (1) The relative force (by calculation) for actual density of loading in shell; (2) specific gravity; (3) density of loading; (4) charge contained in 100 cu. ins.; (5) approximate cost of charge; (6) ease of supply; (7) method of loading; (8) safety in manufacturing; (9) stability in heat test; (10) non-hygroscopic; (12) non-active on metals.

If the above were satisfactory the explosive was tested in an impact testing machine devised by Captain Dunn, a member of the board. In this is provided a shallow cup in an anvil capable of holding a few grains (by weight) of the explosive in such a manner as to prevent lateral expansion.

By noting the height of fall of a known weight, the relative insensitiveness is determined. It is of interest to know that, in every case, subsequent armor tests have borne out the conclusions reached with this little machine. Having once determined a limiting drop, below which an explosive would fail in a gun, it is easy to reject, without firing, all those below that limit, and indeed select only those approaching a higher drop limit that would indicate insensitiveness to impact.

A projectile acquires its velocity in passing over the entire length of the bore of a gun, but, if stopped by an armor plate, is arrested in a very small fraction of the first distance. It is, therefore, evident that the shock of impact is the severer test, and it is here that the tests become more interesting.

We have no means of determining the law of retardation in a plate, so for comparison are forced to assume that it is constant over the path. Under this assumption, considering the length of column of the explosive in each service shell, and the armor against which it is tested, it can be shown that the shock to the explosive in a 6-pdr. shell against a 3-in. nickel-steel plate is greater than in any of the service tests. For this reason, and on account of the relative inexpensiveness, the 6-pdr. R. F. gun was selected for the preliminary tests against armor. Standard plates 1 in., 1½ in., 2 in. and 3 in., are used and firings made at each in order, till either the explosive bursts on impact, or successfully resists the highest plate. The results of the first series of tests following this method are as follows:

SUMMARY OF TESTS OF 6-PDR. STEEL SHELL CHARGED WITH HIGH EXPLOSIVES AND FIRED (UNFUSED) AGAINST STEEL PLATES OF VARYING THICKNESS.

PLATES.—Braced against 6-in. oak backing (110 ft. from gun) with intervening clear space of 20 ft. to stand butt in rear—so placed in order to observe action of shell after penetrating target, and to collect fired shell or their fragments from the butt. The following plates were used: Carnegie tempered (nickel steel) plates, 36 × 36 ins., 1, 1.5 and 2 ins. thick; Fragments of mild steel plate, 3 ins. thick: Carnegie tempered (nickel steel) plate, 38 × 40 ins., 3 ins. thick.

Table Showing Results of Preliminary Tests of High Explosive 6-Pdr. Shells Fired Against Armor Plates from 1 in. to 3 ins. Thick.

Shell charge.	No. of rounds.	Plate thickness ins.	Action of shell.
Sand.....	2	1.5*	Penetrated target; recovered whole.
Black powder.	1	1.0*	Penetrated target and burst 4 ft. in rear.
" "	1	1.5*	Penetrated target and burst close behind.
" "	1	2.0*	Penetrated target and burst 3 ft. in rear.
No. 400 explo.	2	1.0*	Penetrated target and burst 30 ins. in rear.
" "	1	1.5*	Penetrated target and burst close in rear.
Picric acid....	2	1.0*	Penetrated; both had plug blown out between target and butt; low order of explosion.
" "	2	1.5*	Penetrated; one deflected to sea, lost; other exploded violently in backing.
" "	1	2.0*	Exploded in plate; point passed through; base was blown to rear over gun shelter.
Gun cotton...	1	1.5*	Penetrated; recovered whole. Charge slightly set forward at rear.
" "	1	2.0*	Penetrated; exploded in butt.
10% maximite	1	2.0*	Penetrated; entered butt apparently whole; lost.
" "	2	3.0†	One penetrated, recovered whole; charge not disturbed. Other stuck in plate, base imbedded 1.5 ins.; charge slightly set forward at rear.
25% maximite	1	1.5*	Penetrated; recovered whole; charge not disturbed.
" "	1	2.0*	Same, except charge slightly set forward at rear.
" "	2	3.0†	One penetrated; recovered whole; charge slightly disturbed at rear. Other stuck in plate, head half through; not exploded.
Explosive "D"	2	2.0*	Penetrated; recovered whole. Charge slightly disturbed at rear.
" "	2	3.0†	One, same as above; other stuck in plate; broke in two across middle; explosive not ignited.

*Tempered. †Mild steel plate.

PROJECTILES.—6-pdr. A. P. shell, steel, for which the acceptance test requires penetration of a 3-in. mild steel plate, without fracture, base fuse dismantled and brass fuse stock cut off to be flush with the rear end of shell cavity when screwed home; hollow in stock filled with plaster of Paris. The projectiles were filled, flush with the inner end of fuse hole through base, with the following explosives: (1) Black musket powder, filled loosely into shell cavity—average charge 4 oz. (2) Rendrock Co.'s No. 400 explosive, heated to pasty condition, and tamped with wood stick in shell cavity—average charge 9.08 oz. (3) Picric acid, melted and poured into shell cavity—average charge 6.41 oz. (4) Gun-cotton pellets containing 15% moisture, loaded with matrix formed of 60 parts paraffine, 25 parts resin, and 15 parts beeswax—average charge 2.025 oz. (5) 10% Maximite, melted and poured into shell cavity—average charge 5.85 oz. (6) 25% Maximite, melted and poured into shell cavity—average charge 6.075 oz. (7) Explosive D in powder, tamped as well as possible with wood stick through fuse hole—average charge 4.375 oz.

It is seen from the table that the black powder, No. 400 explosive, and picric acid, all failed to penetrate the 1-in. tempered-steel plate without explosion; some superiority for picric acid is only shown in that the explosion was less violent than with the other two. The 1.5-in. plate produced a violent explosion of picric acid as well as of black powder and No. 400 explosive. Gun-cotton passed the 1.5-in. plate test, but failed with the 2-in. plate. The two grades of maximite and explosive "D" passed the 2-in. plate test and also the test with 3-in. mild steel to which they were subjected. A 3-in. tempered-steel plate was then mounted to give an extreme test for these explosives. The powder charge was increased to give a striking velocity of 1,920 ft. secs., with which four rounds were fired, and also two rounds fired with a charge giving a striking velocity of 1,970 ft. secs., viz.:

Velocity, 1,920 ft.-secs.

Shell charge.	No. of rounds.	Plate thickness ins.	Action of shell.
10% maximite	1	3*	Struck squarely, point passed 4½ ins. beyond front face of plate; shell in fragments, rebounded, leaving clean hole; explosive ignited, as shown by clowd of smoke.
	1	3*	Point penetrated about 4¼ ins.; shell rebounded 110 ft., badly set up; no explosion.
Explosive "D"	2	3*	One with same penetration as preceding; other striking somewhat obliquely, penetrated about 3 ins.; both broken; explosive formed cloud of powder; not ignited.

Velocity, 1,970 ft.-secs.

Shell charge.	No. of rounds.	Plate thickness ins.	Action of shell.
25% maximite	1	3*	Badly upset and broken on plate. Cup-shaped hole 1.5 ins. deep. Explosive ignited, as shown by cloud of smoke.
Explosive "D"	1	3*	Same as preceding, except hole 1.7 ins. deep; explosive formed a clowd of powder, did not ignite.

These tests led to the selection of two explosives, namely, maximite and explosive "D," as worthy of final test.

Owing to the impossibility of controlling the explosives in an ordinary explosive chamber, fragmentation tests are made by burying the larger shell, fully charged and fused, about 10 ft. in sand and firing the fuse electrically. Fragments are then dug out, weighed and counted. Careful search is made for any unexploded material. The following extract from these fragmentation tests gives an idea of the results obtained:

(1) 12-in. A. P. shell, Maximite, buried 10 ft. in sand; Frankford Arsenal A. P. detonating fuse.

	Lbs.	Oz.
Weight of empty shell and fuse.....	960	4
Weight of explosive charge.....	50	12
	1,011	0
Weight of metal recovered.....	827	7
Number of fragments counted.....	3,690	
Number of fragments, small pieces estimated....	2,718	

(2) 12-in. A. P. shell charged with explosive "D," buried 12 ft. in sand; Frankford Arsenal detonating A. P. fuse.

Weight of empty shell and fuse.....	951	4
Weight of explosive charge.....	57	12
	1,009	0
Weight of metal recovered.....	815	0
Number of fragments.....	850	

The first result quoted above is much above the average, and has not been duplicated. Indeed, there is a limit to the size of useful fragments. A large number of fair-sized fragments driven with high velocity throughout the interior of a vessel would cause more damage than a much larger number of small fragments. Such a statement is always subject to modifications; if, for example, a shell should burst in a crowded part of the vessel as was the case in the turret of the Japanese flagship at the battle of the Yalu, the more violent explosion would be more disastrous.

Both explosives having met all requirements up to this point, there remained the final tests against armor.

Twelve-inch armor-piercing shot having sufficient velocity for penetration, are required to pass through a 12-in. face-hardened plate before the lot represented by the projectile is accepted. This was, therefore, adopted as the final test for the explosives, namely, that they must withstand the shock of impact of such a projectile on such a plate. It was led up to by firing first a 5-in. shell through a 3-in. tempered plate. Next, a 12-in. A. P. shell through a 7-in. tempered plate, and finally a 12-in. A. P. shot (capped) through a 12-in. harveyized plate. All the above were unfused, and, in every case, the projectiles were recovered and, later, fragmented to increase our data on this subject.

It should be stated that all armor plates are supported by heavy backings of oak strongly braced, and in rear of this is a large mound of sand in which the projectile finally comes to rest. At last the final test was reached. Imagine the tensions as, from a safe distance, we stood with eyes to our glasses anxiously watching the distant field. The target, a 5¾-in. tempered-steel plate, well backed with oak, defiantly faces the long slender 12-in. rifle. The red flag waves from the firing bomb proof. It is answered. The flag falls, a bank of smoke from the gun, a flash of light at the plate, a dense, black, forboding mass of smoke interspersed with flying timbers and bits of plate, two mighty roars in quick succession, a sigh of relief and satisfaction from the observers, and, for the first time, a 12-in. armor-piercing shell, loaded and fused, has passed through heavy armor. While, later, heavier plates were used and the results therefore more satisfactory, the first success ever stands out most vividly in the minds of the experimenters. The official record of this test reads as follows:

No. 7. 12-in. A. P. shell charged with explosive "D," 58½ lbs. Weight of charged shell complete, 1,021 lbs. Fired March 27, 1901, with Frankford Arsenal detonating A. P. fuse complete against 5¾-in. tempered-steel plate. Striking velocity, 1,475 ft. secs. Shell penetrated plate and detonated immediately in rear. Plate broken and carried forward with numerous fragments of shell.

Tests against 7-in. steel plates and 12-in. face-hardened plates followed with great success. Finally, encouraged by the successful results, a 12-in. A. P. shell (the test of which is a 7-in. steel plate) was fired against a 12-in. face-hardened plate. The record reads:

No. 11. 12-in. A. P. shell charged with explosive "D," 58.6 lbs. Weight of charged shell complete, 1,010 lbs. Fired May 17, 1901, with Frankford Arsenal detonating A. P. fuse complete against a piece of 12-in. face-hardened steel plate. Pressure in gun, 20,000 lbs. per sq. in. Velocity about 1,875 ft. secs. Shell detonated in plate and completely demolished plate and backing—all being carried forward and swept away. Fragments of plate were thrown to a distance of 200 to 300 ft., and gave evidence that the plate was penetrated by the shell.

In summing up the final tests we find:

	Explosive "D."	Maximite.
Shell fragmented by detonating fuse	8	11
Shell fired from gun unfused	13	13
Shell fired from gun fused	13	10
	34	34
Results entirely satisfactory with respect to explosive	34	33
Premature action of explosive, cases afterward remedied	—	1
Fused acted feebly—remedied	3	1
Fuses failed	1	—

Before closing, it is necessary to mention a most important factor in this success, namely, the fuse. But, of this, little can be said. It is the secret of all our triumphs, and as such is being carefully guarded. It, like the explosive, passed through various stages. It was tested separately for its power to detonate the shell charges; its power to resist shock of discharge and impact; and, finally, under service conditions. It had its failures in the early stages, but, thanks to the skill and energy of Captain Beverly W. Dunn, Ordnance Department, U. S. A., won out in the end.

One of the most serious questions connected with an armor-piercing fuse is its delay in action. Introducing, as it does, the time element, it is evident that an interval suited to light armor would not be satisfactory for heavy when the time of penetration is greater. As by far the greater part of a ship's protection is relatively light armor, a delay sufficient to cause detonation a few feet after penetration seems best. This gives us a burst when a shot is still in the 12-in. plate, but has penetrated.

I think I am safe in saying that the results just enumerated are unique, and so far surpass those previously obtained as not to admit of comparison with them.

A NEW ELECTRIC COAL-CUTTING MACHINE.

One of the latest developments in coal-cutting machinery is a machine of the chain type which is adapted for both breast and longwall work. The frame or bed is about 12 ft. long, and the outer end of the frame, about 5 ft. long, can be disconnected from the rear portion. On this frame travels the box or casing in which are mounted the motor and the gears for driving the chain and the feed, while to this casing is attached the frame which carries the cutter chain. A special feature of the construction is that the motor is mounted with its shaft in a vertical position, so that its pinion gears directly with the spur wheel on the shaft for driving the cutter chain. A worm gear drives the pulleys or drums for hauling on the feed chain. Fig. 1 is a general view of the machine, showing the position of the motor and chain frame at the end of the advance or breast cut. The total weight of the machine is about 5,000 lbs., and it is operated by a 30-HP. motor.

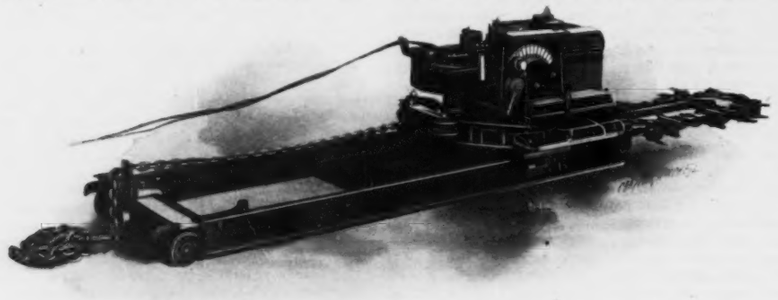


FIG. 1. A NEW ELECTRIC COAL CUTTING MACHINE.
Sullivan Machinery Co., Chicago, Ill., Makers.

To begin work at a face, the upper section carrying the motor cutting channels is run back on the main frame, which is then moved up till its front end is against the face to be undercut. The motor is then started and the upper section is fed forward on the main frame as the cutters work their way into the coal by means of a feed chain made fast to the front end of the frame and passing around grooved pulleys on the motor casing.

For the ordinary breast machine, as soon as the cutter head has reached the end of the travel it must be backed out and the machine shifted sideways to put it in position for making another cut. In the new machine, however, when the machine has reached the limit of its breast cut, it is carried on the shorter section of its frame, and the longer section is disconnected and removed. It then begins to work as a longwall machine, traveling laterally across the room at right angles to its former travel, and Fig. 2 shows this work in progress. It travels on its own base, is self-propelling, no skids or track being required. Thus no time is lost in backing out and shifting the machine, and there is no stoppage necessary from the time the first advance cut is started until it is withdrawn after having undercut the entire face.

Owing to the construction of this machine, it holds itself under the coal while traversing across the face without the use of jacks. This is a matter of considerable importance, since it does away with the necessity for the extra (third) man required on other longwall machines, whose duty is to simply shift the heavy jacks which hold the cutter under the coal as the machine advances.

In making its lateral cut the machine advances by means of a feed chain, the extremities of which are fastened on opposite sides of the room. The machine starts at one corner and pulls itself toward the other extremity of the chain, making a floor cut of uniform smoothness, with no ridges or pockets at the back. The depth of undercut is under the control of the operator by simply tightening or loosening the feed chain by means of the special jack. By loosening the chain the rear of the machine is thrown to the left, the front of the cutter bar is thrown off the coal, and the machine will run out from under the coal of its own accord. On the other hand, by tightening the chain, the rear of the machine is pulled toward the jack and the cutter bar will be pulled deeper into the coal.

For work in hard or soft coal it is necessary to have the machine equipped with several sets of feed gears, the hard formations requiring a slow feed, which not only increases the efficiency of the machine, but lessens the delays caused by resetting dull bits. These feeds run from 14 ins. per minute in hard coal to 42 ins. per minute in soft coal. If the machine is provided with a 6-ft. cutter bar, with the feed at 42 ins., it will cut 21 sq. ft. of coal in one minute.

This machine can be operated successfully in mines with bad roofs, as ample clearance is given the machine with the props set 6 ft. from the face. With the ordinary type of breast machine it is necessary either to have at least 12 ft. between the face and props or to move these props continually to make room for the machine, which is a dangerous proceeding under a bad roof. One of the great advantages of this machine, from the miner's standpoint, is the fact that there is practically no heavy labor connected with it. It is loaded, unloaded and moved about the room by its own power, doing away with the heavy bar work necessary to move the ordinary machine after every advance cut.

FIG. 2. COAL CUTTING MACHINE MAKING LONGWALL CUT.
(This cut is at right angles to the breast cut, and the main frame is removed.)

This new coal-cutting machine is being introduced by the Sullivan Machinery Co., of Chicago, and we are indebted to the makers for information respecting it. We are informed that the world's record for coal cutting was recently made with one of these machines in the Dickason Mine, at Linton, Ind., where a run of 360 ft., with 6½ ft. undercut, was finished in eight hours. During this run the machine was moved to six different faces and was operated from start to finish by only two men.